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OF THE

DEPARTMENT OF THE INTERIOR

FOR THE

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REPORT OF THE DIRECTOR OF FORESTRY.

FORESTRY BRANCH,
OTTAWA, April 1, 1913.

W. W. CORY, Esq., C.M.G.,
Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to submit the report of the work of the Forestry Branch for the year 1912-3 and also the reports of the officials in charge of the different divisions. During the year the administration of the Irrigation Act was withdrawn from this Branch and will be separately reported on.

STAFF.

Last spring ten graduates of forest schools were added to the staff, but eleven resigned from the staff later to take service with the newly formed Forest Service of the province of British Columbia. Mr. A. Knechtel, who acted as Inspector of Forest Reserves, was transferred during the year to the Parks Branch. At the present time there are on the staff seventeen graduates of forest schools, and the total permanent staff is as follows:—

Head Office at Ottawa	32
Inspectors	5
Forest Supervisors	12
Forest Assistants	4
Forest Rangers	46
Inspectors of Free Plantations	8
Outside clerical staff	9

Neither the staff nor the accommodation for it is yet adequate for the work which should be done, and work seemingly effective in favourable years may be lost by fire in dangerous seasons where the staff is not sufficient to have the necessary permanent improvements and preventive measures completed or to provide sufficient patrol. The permanent improvements are also certain to be more costly if there is not proper supervision and checking, so as to ascertain the directions in which the cost of construction may be running high and keep it within proper limits. Nowhere is this inadequacy of staff and accommodation therefor more marked than at head office, and I would again emphasize as I did last year the necessity for an adequate staff and organisation at head office if the administration and the records are to be kept in proper order.

The absolute urgency and necessity for fire-preventive measures of the most efficient kind is well illustrated by the report of Mr. J. A. Doucet, referred to later, on timber areas in the Athabaska and Peace River valleys. Young timber from 35 to 75 years old covers an area of 2,060 square miles, and young reproduction an area of 1,408 square miles, a total of 3,468 square miles, or 2,219,520 acres. To reforest such an area by replanting would cost, at the rate of $12 per acre (and it could hardly be done for less), $26,634,240. Nature has done the work at no cost and asks us only for protection. When mature, this timber, at 5,000 feet, board measure, to the acre,

would amount to 11,097,600 feet, board measure, and at a return of $1 per thousand feet, board measure, would return to the Government $11,097,600, while its actual value to the industries of the country would be ten times as much.

When young timber is burned it is frequently the case that there is no seed-supply left and reforestation by natural means is an impossibility or is delayed so as to become the work of centuries.

APPROPRIATION.

The appropriation for the year 1912-3 was $362,500, and the expenditure was divided as follows between the various services:—

Salaries at Ottawa	$ 12,000
Travelling Expenses	5,000
Forest Reserves	169,300
Fire-ranging	99,000
Printing and Stationery	10,000
Tree Planting	49,500
Forest Surveys	13,000
Statistics and Products	4,700

In regard to the appropriation I may point out that though apparently large when compared with appropriations which have been provided for forestry work in Canada, it is small compared with what is provided in other countries.

In the United States the federal appropriation for the Forest Service is $5,500,000; in India, it is $4,000,000; in Russia, $10,000,000; in Sweden, $595,000.

CORRESPONDENCE.

The letters received and sent out by this Branch are as follows:—

Number of letters received		21,101
Mail sent out—		
Letters, circulars, &c	60,410	
Bulletins and reports	34,053	
Parcels	2,248	
Total		96,711

LIBRARY.

The library of the Branch now contains some twelve hundred volumes. Many of the volumes are gifts or exchanges, especially from other Government forestry organisations and from forestry societies and associations. Many, however, have been purchased. A considerable proportion of the volumes, including some of the most valuable and useful, consists of collections of pamphlets which have been bound. The publications of the United States Forest Service and of the Indian Forest Service are especially valuable; they are secured by exchange with the publications of this branch.

During the fiscal year 1912-3 there were added to the library by purchase seventy-nine volumes, and ninety-one volumes of pamphlets and periodicals were bound.

It is hoped shortly to start smaller libraries in the offices of the district inspectors and of the reserve supervisors, so as to have convenient for reference works which will be of most use to these officers and their assistants.

There is received in the library a total of fifty-eight magazines and periodicals. These are for the most part forestry and trade publications, including the publications of the International Institute of Agriculture. Of the magazines most are Canadian or United States publications, three are from England, two from Germany and one

each from Austria, India, Sweden and Tasmania. Some of these are kept and bound, and in all cases the important articles are preserved and indexed. This part of the work has during the year been greatly advanced by the Assistant Librarian, appointed last summer.

In work which is developing with the rapidity with which forestry has of late been developing on this continent, much of the literature appears in the form of pamphlets, issued by the various governments, forestry societies and individuals. Much of the work of the library is given to collecting, classifying and binding these.

An important part of the library consists of the photographs, of which there are now considerably over five thousand. This collection consists almost entirely of photographs taken by the officers of this Branch while in the field, and has been accumulating almost from the establishment of the Branch. The development and printing of the negatives are done in the departmental photographic laboratory, but the work of receiving, listing, storing and indexing of the photographs is done in the library of the Branch. Illustrations for reports are selected from this collection and photographs are lent for use in illustrating books, reports, magazines, newspapers and other publications.

A small collection of lantern slides, now 325 in number, is also kept in the library. These slides are used by the Branch officers to illustrate lectures and addresses, or are lent on request.

To show how important a factor the library has become in the work of the Forest Service of the United States Department of Agriculture it will be sufficient to note that, according to the report of the Chief Foresters of that Department for 1912, the number of volumes in their library at Washington was 16,017, while in the district and supervisors' offices and other branches of their work outside of Washington there were 20,827 volumes. The additions to these libraries during the year were, respectively, 1,054 and 2,894. The sum of $2,000 was spent on the field libraries during the year. The district libraries number some 500 volumes or more, while the supervisors' libraries comprise 75 or more volumes. The total number of photographs in the Forest Service library was 29,133, of which 4,053 were added during the year.

STATISTICS.

The work of collecting statistics on forest production and consumption of forest products is being reorganized under the supervision of a technical forester.

Statistics on production include lumber, lath and shingles, pulpwood, poles and cross-ties and tight and slack cooperage. Annual bulletins are issued covering these four classes of products. The bulletins for the calendar year 1912 will be ready for distribution in the summer of 1913. A review of the statistics gathered by this branch for the years 1908, 1909, 1910 and 1911 is being undertaken, and a similar review will be made every five years. It is intended to resume the collection of statistics concerning the consumption of wood in mining operations, and a bulletin on this subject will be issued covering the calendar year 1913. The gathering of these annual statistics necessitates correspondence with over 3,000 firms and individuals. The work of compiling statistics from this mass of correspondence has been greatly retarded by lack of an adequate, permanent head-office staff. A strengthening of this staff would greatly enhance the value of the reports issued.

In addition to the head-office staff, a field organization is necessary, composed of men familiar with local conditions who can gather statistical information by personal visits. The services of such an official for the Maritime Provinces has been arranged for. The services of similar men in other provinces, co-operating with the provincial administrations where possible, will be of great advantage.

These annual statistics are to be followed by special studies of the wood-using industries of the various provinces. Such a study covering the province of Ontario

was completed in 1912, and the results in bulletin form will be issued shortly. A study covering the three Maritime Provinces is now being undertaken and will be completed in the summer of 1913. The other parts of the country will probably be taken up in the following order: first, the three Prairie Provinces; then Quebec, and afterwards British Columbia. These studies will be made at the rate of one a year, returning finally to Ontario and commencing a new rotation so that each region will be studied once in five years.

Special work in connection with forest products will be undertaken, and is discussed elsewhere in this report. At the Head Office a study of the structure of wood species is being made with a view to publishing a bulletin on Canadian commercial woods and a key to their identification. A collection of western coniferous woods has been completed for this work. The need for such a bulletin is shown in the confusion that is constantly arising due to the misuse of common names of wood species. An attempt will be made to standardize these common names.

The statistics compiled up to the date of this report include those relating to pulpwood, poles and cross-ties.

Canada produced in 1912 a total of 1,846,910 cords of pulpwood, valued at $11,911,415. One half of this total quantity, or 980,868 cords, valued at $6,695,833, was exported to the United States in the raw or unmanufactured form. Canada manufactured 866,042 cords of pulpwood, valued at $5,215,582, in her own mills, and the estimated quantity of pulp produced thereby was 682,632 tons, 'air-dry.'

Canadian railways in 1912 purchased 21,308,571 cross-ties valued at $9,373,869. About four-fifths of these were the product of Canadian forests. In addition to the ties purchased by Canadian railways Canada exported to the United States 539,788 cross-ties valued at $186,170. This brings the total value of ties cut in Canada in 1912 to $7,862,608.

Telegraph, telephone, electric light and power companies reported the purchase of 608,556 wooden poles valued at 1,113,524. Probably ninety-five per cent of these were cut in Canada and, allowing for the export of this class of product, it is safe to assume the above figures to represent the value of Canadian poles cut in 1912.

An estimate of the total value of the different classes of forest products is given below. The figures are rounded to hundreds of thousands and form as reliable a summary as possible with the date available:

Lumber, lath and shingles	$ 84,000,000
Firewood	50,000,000
Pulpwood	12,000,000
Posts and rails	10,000,000
Cross-ties	8,000,000
Square timber exported	1,900,000
Cooperage	1,700,000
Poles	1,200,000
Logs exported	1,100,000
Tanning material	1,000,000
Round mining timber	600,000
Miscellaneous exports	300,000
Miscellaneous products	10,500,000
Total	$172,300,000

TREE PLANTING.

The tree planting on the farms on the prairies was the first work taken up by the Forestry Branch and it remains one of the most important. The underlying purpose of the work of the Forestry Branch is to provide for the settler and the man desiring to make a home some of the main necessities for that purpose conveniently

situated and at a reasonable rate, and the supplying of trees for planting on prairie farms is a direct following out of that purpose and has helped in the establishment and beautifying of homes that in rural attractiveness cannot be surpassed in any part of the Dominion.

In the spring of 1912, 2,729,135 trees were distributed to 3,618 applicants, bringing the total distribution up to 21,650,660 trees.

The number of inspectors of tree plantations employed on the work was eight. The work done by the inspectors in educating the public and ensuring the success of the plantations is very important. That there has been practically no complaint from the public as to the work of the inspectors, while commendation of their services is not rare, is a tribute to the character of the inspectors and the good judgment with which their work has been done and reflects credit on the whole administration of their division of the Forestry Branch.

The additional half-section near Saskatoon purchased for the purpose of enlarging the nursery was not acquired in sufficient time to permit of any development work being done during the past year. The arrangement for the erection of necessary buildings is being made by the Department of Public Works. The land was kept cultivated last year in order to keep it clear of weeds and in good condition for seeding with nursery stock.

It is becoming more apparent all the time that for the necessary office-work at Indian Head some better accommodation than that now provided should be obtained. A suitable building for this purpose cannot at present be obtained in Indian Head and provision for the erection of such a building should be made.

FOREST RESERVES.

The organization and equipment of the Forest Reserves is the most important part of forest administration, inasmuch as they are the final and permanent form of the forest, and in them the management may be developed on permanent lines towards the perfected system of older lands. The systems of forest management in Europe, in the United States and elsewhere have been and are being studied, so that the methods followed here may be advanced as rapidly as possible. Improvement works of various kinds have been carried out, the regulations for cutting timber have been improved and the supervision has been closer.

Organization.—In order to systematize the administration of the forest reserves, they have been divided into four inspection districts, namely, Manitoba, Saskatchewan, Alberta and the Railway Belt in the province of British Columbia, with a district inspector in charge of each. The work of the district inspector is to lay out, in consultation with the officers directly in charge of the reserves, the organization of the reserves, the works necessary for their protection and improvement, and the appropropriation necessary, and to submit to the Director their recommendations in regard to these and other questions of methods and policy. It is also the inspectors' duty to inspect the books and records in the reserve offices, to check the expenditures so as to ascertain whether the improvement work is being done at reasonable cost, and to make such field inspections as may be necessary to determine that the work is being properly carried out. The working out of improvements in methods of lumbering operation so as to provide for prevention of fire and the reproduction of the crop will also be largely guided by the inspectors. The position of inspector therefore requires high administrative, as well as technical, qualifications.

In charge of each reserve is an officer designated a Forest Supervisor. The supervisor has charge of the rangers and the work on the forest reserve. He lays out the districts for the rangers, directs and supervises their work, plans the improvement works, such as trails, roads, telephone lines, lookout stations, &c., supervises the timber

operations and reports on applications for timber, has charge of timber surveys and fire-fighting. The supervisor requires good administrative ability and should have technical knowledge as well as practical experience.

The forest ranger, having charge of a district in a forest reserve, is in some respects the most important officer on the reserve, as he is charged with the actual carrying out in his own district of the work laid out. He does the cutting of roads and trails, the building of telephone lines, ranger stations and lookout stations, with necessary help at times, patrols for fire, does fire-fighting, cruises timber, supervises timber cutting and generally looks after his district.

The qualifications which a forest ranger should have are the following:—

1. Physical fitness, to be attested by medical certificate.
2. Age, which on appointment should be between 21 and 45.
3. Experience in bush work, including scaling and cruising of timber.
4. The running of a line by compass and determining distance by pacing.
5. The packing of horses in some districts.
6. Reading, writing and arithmetic sufficient to read instructions, write replies to letters and calculate the dues on any of the ordinary permits issued on forest reserves.

It is not possible at the present time to obtain many men having the full training and qualifications required for the position of ranger, and it is considered that it would be advisable to establish a ranger school for the purpose of giving them the necessary training. In all countries where forest services are established on a permanent basis—Germany, France, Sweden, Russia—such ranger schools are in existence, and the government of the United States found it necessary to establish such a school in connection with its Forest Service. The question may be raised as to whether such schools should not be established in connection with universities or agricultural colleges, but at the present time this is impossible. The colleges at the present time could not obtain the staff with the necessary experience, and it is doubtful if men could be got to attend such schools unless assurance was given that those who took the course would be given first consideration in appointments. A forest-ranger school for the training of men already on the staff could be carried out on one of the reserves by experienced officers of the staff of the Branch, and the taking of the course successfully should be a requirement before final confirmation of an appointment as permanent.

In the meantime for all appointments of forest rangers the following minimum of qualifications should be required:—

1. Physical fitness.
2. Age between 21 and 45.
3. A reasonable knowledge of bush work.
4. A sufficient knowledge of reading, writing and arithmetic to do the ordinary work of the reserve.

The permanent forest reserve organization consists of the following officers:—

District Inspectors	4
Supervisors	12
Forest Assistants	4
Forest Rangers	46
Total	66

Improvements.—The improvements mentioned below were carried out on the reserves during the year, and the cost given includes the value of the time of the permanent forest rangers taken up on the different works. Practically all main-

tenance work is done by the rangers. The following is a tabulated statement of these improvements and their cost.

—	No.	Total cost.	Average.
		$ cts.	$ cts.
Rangers' houses	10	10,536 33	1,053 63
" stables	10	1,925 87	192 59
" cabins	15	4,160 40	277 36
Roads ... Miles.	103.75	5,126 24	49 50
Trails—new ... "	175	8,752 85	50 01
Trails—old ... "	191	1,225 14	6 42
Bridges	10	1,210 31	121 03
Fire-guards—			
Cleared ... Miles.	66.2	6,205 86	93 74
Ploughed ... "	101	931 73	9 22
Telephone line ... "	100	9,903 19	99 03

A reduction in average cost should be made on almost all these items when the staff is better trained and more experienced.

The carrying out of such improvements will steadily bring about conditions on the forest reserves that will locate the rangers at most convenient points, make all parts of the reserves accessible and, finally, with proper disposal of the debris from the cutting of trees, make the reserves immune from fire under care of a reasonable patrol.

Timber.—The regulations for the cutting of timber on the forest reserves heretofore established were framed with a view to supplying only the requirements of settlers, but regulations for the supply of a larger demand are now necessary. Small mills, mines, irrigation works, municipal works, schools, churches and other uses must be met, and recommendations for regulations to meet these requirements have been submitted.

The cutting of timber under settlers' permits is large on some of the reserves. For instance, in the Riding Mountain Forest Reserve the quantity of timber cut under settlers' permits was 1,729,759 feet, board measure. It is found rather difficult to control this cutting so as to have the timber taken out economically and to leave the bush in good condition. It was therefore considered advisable to make the experiment of allowing a few small mills to locate on the reserves to cut timber under settlers' permits. Three mills were allowed on the Riding Mountain Forest Reserve last year and were allowed to operate during the past winter. The privilege was subject to the following restrictions in regard to operations:—

1. Stumps shall be cut with saws and must not be cut higher than 18 inches.

2. There shall be taken and cut into lumber from every tree all portions suitable for such purpose, to the satisfaction of the forest officer.

3. The brush and debris shall be lopped and scattered or placed in compact pil s for burning to the satisfaction of the forest officer.

4. As little damage as possible shall be done to young growth.

Some of the mill-men have tried to get out of following these regulations as much as possible, and in such cases the results have not been satisfactory. In such cases a renewal of the privilege should not be given. Other mill-men have faithfully followed out the requirements above outlined, and in these cases there has been a distinct advance in the character of the operations and in the condition in which the forest is left. The debris has been piled in good order and the danger of fire will thus be greatly decreased, while forest reproduction is encouraged.

Several small sales of timber were made in the Rocky Mountains Forest Reserve, subject to similar restrictions.

While an effort is thus being made to improve operations on new disposals in the forest reserves, the operations on licensed berths in the reserves disposed of prior to the creation of the reserves have not been improved, and, contrary to the spirit and intention of the Forest Reserves Act, however correct it may be according to its letter, the authority of the forest reserve officers to take any steps in that direction has been taken away. The licenses make provision for such improvement as is necessary by the following sections:

(a) The licensee shall not have the right under his license to cut timber of a less diameter than ten inches at the stump except such as may be actually necessary for the construction of roads and other works to facilitate the taking out of merchantable timber and shall not have the right to cut any trees that may be designated by the proper officer of the Department of the Interior as required to provide a supply of seed for the reproduction of the forest.

(*e*) The licensee shall take from every tree he cuts down all the timber fit for use and manufacture the same into sawn lumber or some such saleable product, and shall dispose of the tops and branches and other debris of lumbering operations in such a way as to prevent as far as possible the danger of fire in accordance with the direction of the proper officers of the Department of the Interior.

(*f*) The licensee shall prevent all unnecessary destruction of growing timber on the part of his men and exercise strict and constant supervision to prevent the starting and spread of fires.

These provisions of the licenses contain all that is necessary to make the operations satisfactory both from the standpoint of prevention of fire and reproduction of the timber. When such requirements are enforced on all other operations on the reserves and the power to enforce them on license berths exists without being put into operation, it is an unfair discrimination against the new and the small operators. Further it results in the best timberlands in the reserves, which are usually those in licensed berths, being left exposed to greater danger of fire and without any effort to control the forest crop that is to follow after the removal of the present one.

TIMBER SURVEYS

The exploration of the public lands to determine those which are non-agricultural and which should be, therefore included permanently in forest reserves was continued by seven parties.

One party, under charge of Mr. L. C. Tilt, explored the district in southeastern Manitoba from the eastern boundary west to Range 6 east Principal Meridian, and from the international boundary north to Township 20, an area of some 3,500 square miles. The western part of the tract is prairie, which, going eastward, passes into muskeg, with sand ridges occurring in places, and finally reaches the rocky Laurentian area. The timber is jack pine on the sandy ridges, with spruce and tamarack on the lower ground. The sand ridges are not, and will not be, agricultural land, and the muskegs at present are not, but with a good system of drainage the muskegs may be reclaimed and made good agricultural land in time. Consequently, in considering the lands that should be included as a forest reserve, only the sandy ridges were included and a recommendation, which, however, has not yet received approval, is made that a tract of some 260 square miles of such lands should be set apart as a forest reserve.

The edge of the rocky Laurentian area which borders the muskeg to the east and north was not sufficiently defined by the survey to lay down an absolute line for the beginning of the non-agricultural lands, and a further survey will be made for this purpose.

One of the special points brought out in the report is the possibility of a large increase in the area of agricultural lands in the Province of Manitoba by a system of drainage of the muskegs similar to that carried on in the case of lands of the same character in the state of Minnesota, immediately to the south.

Mr. Tilt's report is being published separately.

Another party, under charge of Mr. W. L. Scandrett, examined the district west of the Porcupine Forest Reserve in the province of Saskatchewan. This tract is a most important watershed covering the head-waters of the Assiniboine river, which waters such an extensive district in the provinces of Saskatchewan and Manitoba, and of the Swan and Red Deer rivers, two of the chief tributaries of Lake Winnipegosis. The examination covered only an area along the outer side of the tract which would determine the boundaries of the lands which are best suited for forest purposes, and the inspection will be continued so as to get a fuller knowledge of the interior. Enough information was obained, however, to determine the boundaries of the tract which should be included in a forest reserve. The land is generally covered with spruce, tamarack and poplar, and should be capable of producing good crops of timber. Mr. Scandrett's report is attached.

A third party under Mr. C. H. Morse examined a district north and west of Prince Albert. The tract examined has borne, and a large proportion of it still bears, a good stand of timber, consisting mainly of spruce and jack pine. It forms the present main source of timber for the operations for companies having their saw-mills at Prince Albert. It is also the watershed between the Saskatchewan and Churchill rivers, and for that reason in addition is of special need of protection. The character of the timber is such as to indicate that the rate of growth would be a good average. On the recommendation made in the report, which is appended hereto, a temporary reservation of an area of 557 square miles has been made.

A fourth party under Mr. S. H. Clark, whose report is appended hereto, examined lands north and east of Lac LaBiche in Northern Alberta which form the watershed of the Athabaska, Beaver and Pembina rivers. The country was a most difficult one to travel in on account of muskegs and wet land, and the timber growth, consequently, is mostly of small dimensions, as is found to be the case in all poorly drained soils in the north. The muskegs are interspersed with sand ridges upon which jack pine grows. Protection of this district from fire will be required for a long period before the trees will attain timber size, and in the end some scheme for the improvement of the drainage may be necessary.

One party under charge of Mr. H. S. Irwin, and later under Mr. F. B. Robertson, examined the lands in the dry district of the Railway Belt in the province of British Columbia. At the time the reserves in that district were established, no careful examination of the lands had been made and the reserves included only portions of the summit-plateau. The inspections made resulted in recommendations for the inclusion of the broken edges of the mountains previously reserved and of some additional ranges that had not been included in reservations. The proposed additions will include almost all of the absolute forest land in the dry district. No agricultural lands have been included. Grazing lands have been excluded as far as possible, but any such lands that may be within the boundaries will be open to access by the public under regulation.

A party under charge of Mr. H. C. Wallin completed the examination of the lands in the coast district of British Columbia north of the Fraser river up to North Bend. This district includes a large area of land which is suitable only for the growth of timber and which now has a stand of good timber which only requires proper protection and management. The chief timber tree is Douglas fir, though cedar and hemlock are also generally found, besides other less important species. The topography of the district is mountainous and from it there flow a number of streams, some of them navigable, which form very important sources of water-power. A recommendation

was made for the establishment of a forest reserve in this district and this would seem to be a locality where such a reserve would be particularly valuable and necessary.

A party under charge of Mr. J. A. Doucet continued the examination of the mountainous or foothill district in Alberta lying south of Lesser Slave lake and westward to the Rocky Mountains forest reserve. The survey was begun last year in the vicinity of Lesser Slave lake by Mr. D. R. Cameron, and the report of this work has already been published.

The area examined was some 7,330 square miles and a large proportion of this is rough broken land and considerable elevation, forming the watershed between the Athabaska and Peace River valleys. South of the Athabaska river and west of the McLeod river the land is generally low-lying and of good quality, and again to the north around Grouard, Sturgeon lake and Grande Prairie, but between these two tracts intrudes the area of elevated, broken and poor land described.

The timber on this tract is lodgepole pine, spruce, balsam fir, tamarack, poplar and white birch. There are very few areas of mature timber owing to recurrent fires. Probably eleven per cent of the area has been burned over in the last twenty years. As a rough estimate Mr. Doucet has calculated that the area examined carries 20,009,600 cords of poplar and birch, of which seventeen millions are poplar. The mature spruce and pine timber covers an area of approximately 364 square miles with a production estimated at 2,839,460,000 feet, board measure. A young forest of spruce and pine well on to maturity covers an area of 1,500 square miles and has a stand of 2,672,680,000 feet, board measure, of these species, with some 2,675,000 cords of poplar and birch intermingled. A still younger forest of spruce, pine, poplar and birch covers an area of 2,060 square miles. This younger forest, if properly protected from fire, will mean an immense source of wealth.

A resumé of the area examined is as follows:—

—	Square miles.	M. feet B.M.	Cords.
Mature spruce and pine	364	2,839,460	....
Mature poplar	1,362	....	17,336,000
Young forest (up to 100 years old) of spruce and pine with poplar and birch intermingled	1,500	2,672,680	2,675,600
Forest of pole size (35 to 75 years old)	2,060	....	....
Young reproduction—spruce, pine, poplar, birch	1,408	....	....
Brulé lately burned	740	....	....
Total	7,434	5,512,140	20,011,600

The mature spruce forest is found largely in the Smoky River valley and the trees run from 5 inches in diameter up to 24 inches and even up to 38 inches. The tract of timber on the Smoky river which is already under license is tributary to the settlement at Grande Prairie and the Peace River valley generally, and for the development of that section it is important that the timber should be thoroughly protected from fire.

Mr. Doucet recommends the inclusion of a large area in a forest reserve in order that the timber so potentially valuable may be protected and preserved for the time when the rapid development of the near future will make it of the utmost value. The proposals for protection include the appointment of some ten rangers with defined districts, the improvement of twelve trails now existing, and the extension of eight of them. Fire-lookout stations were also located.

FIRE RANGING.

The inspection of the fire patrol outside of the forest reserves in Manitoba, Saskatchewan and Alberta was placed under the charge of Mr. E. H. Finlayson, who has

had considerable experience in fire ranging in Ontario, and is a graduate of the forest school of the University of Toronto. The results of this inspection even so far have fully justified the recommendation I made several years ago that such an inspector should be appointed.

The patrols in the Railway Belt in the province of British Columbia are under the inspection of Mr. D. R. Cameron, Inspector of Forest Reserves.

There were twelve fire-ranging districts, each under charge of a chief fire-ranger. The districts and the number of fire-rangers employed were as follows:

District.	Headquarters.	No. of Rangers.
Southern Manitoba	Winnipeg	9
Northern Manitoba	Norway House	12
Pas	Pas	10
Prince Albert East	Melfort	13
Prince Albert West	Prince Albert	19
Battleford	Battleford	8
Edmonton	Edmonton	59
Great Slave	Fort Smith	9
Mackenzie	Fort Simpson	—
Revelstoke	Revelstoke	16
Salmon Arm	Salmon Arm	21
Coast	New Westminster	26
	Total	202

Fortunately the season was a wet one throughout all the western provinces, except for a short time in the spring, and excepting also the Peace River and Mackenzie districts.

One serious fire occurred in the month of June in the vicinity of Golden. It started beside a logging railway in Timber Berth No. 16, which is owned by the Columbia River Lumber Company, and the almost certain conclusion is that it started from a spark from a logging engine. It would greatly decrease the danger on such railways if oil were used as a fuel, as the grades are steep and the locomotives have to work so hard that they are almost certain to throw sparks even when a wire screen is provided. The fire was noticed immediately by the logging crew and also by the fire-ranger, but owing to the debris from the right of way of the road it got such headway that it was soon out of control. Driven by a strong wind it swept toward the town of Golden, and, although it was on the opposite side of the river, only a fortunate change of wind prevented a serious disaster. The timber burned in this fire was several million feet, board measure, and, although a great deal of it will be taken out, it means that the lumber company will have to carry on much more extended operations, whether the market will warrant it or not, and it means a heavy lost in immature timber which in a few years would have been of great value. When in British Columbia I visited the scene of the fire and was pleased to find that full credit was given to the fire-ranging staff for having done everything possible to meet the emergency. It accentuates, however, the necessity for a closer patrol of the districts, a better equipment for reaching fires, but more especially the use of some better fuel for logging locomotives, and the clearing of the debris from railway rights of way and lumbering operations.

It was reported by Mr. G. O. Card, government agent at Fort Simpson, that there were fires along the Mackenzie river last year which did considerable damage, but details were not given. Mr. Card is in charge of the protective service in the Mackenzie district, but has not outlined an organization for its protection. A

steamer which was built in the year 1911 will, it is expected, be placed on the Mackenzie river this season so as to be available for patrol and for taking men to fight fire when necessary.

FIRE PATROLS ON RAILWAYS.

The fire patrols along the railways were carried out by the Department for the first portion of the season, but later, under the legislation amending the Railway Act and under the regulations of the Dominion Board of Railway Commissioners, the railways were required to furnish the patrols under the inspection of the Board of Railway Commissioners and of the Department. The inspectors of fire ranging for this Branch were made officers of the Board and in conjunction with the chief inspector for the Board, after consultation with the railway companies, laid down the patrols that would be required. The inspection by the Department also covers the equipment of the locomotives and the clearing of the right of way of combustible material. Steps are being taken to organize this work thoroughly for the season of 1913, and it is hoped that it will result in efficient protection, even though the season may not be as favourable as that of the past year.

FOREST PRODUCTS LABORATORY.

The question of the establishment of a Forest Products Laboratory has been further considered during the past year, and, as the proposal has been favourably considered by the minister and yourself, it is expected that arrangements for establishing such a laboratory will be carried out during the coming year. Resolutions favouring such a laboratory were submitted by the Canadian Forestry Association and the Canadian Pulp and Paper Association.

The lines of investigation which such a laboratory could undertake and which would be of great value to the industries using forest products in Canada would be as follows:—

1. Timber Physics, which is the study of the physical and structural properties of wood and methods of seasoning and handling. It would also include a microscopic study of the structure of wood and the identification of species.

2. Timber Tests, which include studies of strength, stiffness, hardness and other mechanical properties of woods. This information will be very important where Canadian woods are used in construction or come into competition with foreign woods.

3. Wood preservation, which includes studies of methods of prolonging the life of woods, thus helping to decrease the drain on the forests. Railway ties, construction timbers, paving blocks and many other demands for the use of wood may be better and more economically supplied as a result of such investigations.

4. Wood Distillation: To determine what products can be obtained most economically by distillation from the different species of wood. Alcohol, turpentine, wood creosote and acetates are some of these products.

5. Pulp and paper, which will cover investigations of the fibres of the different species of trees in Canada and their suitability for pulp and paper making, the methods of manufacture employed and the chemical agents used, with a view to fuller use and elimination of waste.

Other lines of investigation will no doubt open up as the work develops, but it is quite clear from the above statement that such a laboratory would have a wide and useful field of operations.

REINDEER.

The reindeer herd, as reported last year, did not reach Fort Smith in the fall of 1911, but wintered some ninety miles south of that point near Fort Chipewyan. There was a plentiful supply of feed for the deer at this point and they wintered very satisfactorily and were in good condition when the spring opened, at which time they

numbered thirty-two. One strayed away in April, leaving the herd numbering thirty-one. There was no natural increase.

During the winter Mr. Nathaniel Gear, the chief herder, visited Fort Smith and located, in company with Mr. A. J. Bell, Government Agent, a place for the deer. This is at Whitefish Lake, about twenty-five miles northeast of Fort Smith, and is where the timber begins to thin out to the barren lands. During the winter two small houses for the herders were erected at this point.

In May the herd were moved to Fort Smith in three scows in tow of the government steamboat *Rey*, arriving on May 20. They immediately started for Whitefish Lake, where they arrived without mishap.

In order to insure as fully as possible the holding of the deer a fence was erected to enclose, for pasture, two square miles of a promontory jutting into the lake, as it was feared that there would be trouble keeping control of the herd when the flies became bad. In June, however, the flies (bulldogs) became so troublesome that the herd ran wild, broke through all barriers and scattered. Every effort was made to collect the herd, but only twelve, all does, have been recaptured. It is exceedingly unfortunate that this should have happened, but I am informed through other sources that the flies were specially bad during the past season and that in the scrub country where the deer scattered it was a wonder that any of them were recaptured.

As the location at Whitefish Lake was now found to be unsuitable for summer range, though well adapted for winter range, Mr. Bell and Mr. Gear made an inspection in September of islands in Great Slave Lake to endeavour to select a suitable place on which to establish a permanent grazing ground for the reindeer herd. The island selected as most suitable is known as Hardisty Island. It is situated about six miles from the north shore of the lake upon the west side of the north arm, which is due north of Fort Resolution sixty miles and south of Fort Rae a similar distance. This island has an area of about six square miles and there is a similar one adjoining it, of an area of about three square miles. There is moss in abundance on both islands and it would be suitable for a herd of 200 reindeer for the next five years. Driftwood is abundant on the shores, and would be sufficient for fuel and building purposes. A sailboat would keep the herders in touch with Fort Resolution, Hay River and Fort Rae during the summer and the first-named post could be reached in one day with reindeer in winter.

Another stampede of the deer occurred in November, and after the round up it was found that one was missing, leaving only eleven.

If the deer pass through the present summer successfully at Hardisty Island in Great Slave lake, so that it is demonstrated that they can be held there satisfactorily, it would be necessary to make an addition to the herd to ensure their permanent establishment and increase. The partial failure of the shipment does not argue anything against the final success of the experiment or the usefulness of the herd. In the first shipment to Alaska made by the government of the United States the loss was much heavier, and the herds there are now one of the greatest sources of wealth of that country.

WOOD BISON.

The patrol of the district in which the herd of wood bison are located was continued by Messrs. G. A. Mulloy and P. McCallum. Several bison were sighted and tracks of larger numbers were seen, but no sufficient data to determine definitely the number in the herd were obtained. The number is estimated between 200 and 300. No wolves were captured, nor was there sufficient evidence to show that they were making any serious depredations on the herd. Copies of Mr. Mulloy's reports are attached.

Respectfully submitted,

R. H. CAMPBELL,
Director of Forestry.

DOMINION LANDS REVENUE—FORESTRY BRANCH, 1912-13.

Reserve.	Timber permit Fees Dues and Rental.	Seizures.	Hay Permits	Grazing	Rental.	Trees.	Oats.	Building Permit.	Irrigation.	Total.
	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.
Beaver Hills	46 00	62 65	4 50							113 15
Cypress Hills	209 65	24 33	187 20							421 18
Duck Mountain	1,827 89	60 55	22 00							1,910 44
Moose Mountain	21 25		77 50							98 75
Nisbet			2 00							2 00
Pines	212 75		9 10							221 85
Riding Mountain	3,015 56	1,301 20	113 40							4,430 16
Rocky Mountain	7,547 61	6,505 25	111 70		81 96			10 00		14,256 52
Spruce Woods	46 50		37 50		30 00					114 00
Turtle Mountain	154 75		117 10	92 75						364 60
British Col. Reserves	0 75		12 00		124 60					137 35
Indian Head Nursery						561 12	345 65			906 77
Land Offices										
Lethbridge									270 85	270 85
Calgary									2,961 12	22,961 12
Medicine Hat									3,712 50	3,712 50
Swift Current									534 10	534 10
Moosejaw									286 25	286 25
Maple Creek									173 17	173 17
Calgary									24,693 59	24,693 59
Irrigation Office									862 00	862 00
Totals	13,082 71	7,953 98	694 00	92 75	236 56	561 12	345 65	10 00	33,493 58	56,470 35

TIMBER PERMITS ISSUED, 1912-13.

Reserve.	No. Permits.	Building Logs.	Roof Poles.	Fence Rails.	Fence Posts.	Lumber.	Ties.	Mine Props.	Fuel.	Dues.	Agency.
		Lin. ft.				Ft. B. M.		Lin. Ft.	Cords.	$ cts.	
Beaver Hills	100	3,460	....	....	....	103,151	....	....	1,156	46 00	Yorkton.
Moose Mountain	16	....	....	....	....	....	....	....	156	21 25	Estevan. Regina.
Cypress Hills	321	576,465	86,700	106,600	103,995	....	....	....	3,582	113 28	Medicine Hat.
The Pines	53	34,245	2,600	10,000	4,100	....	....	....	1,150	203 80	Prince Albert.
Cooking Lake	4	200	700	3,800	420	14,250	....	....	10	1 00	Edmonton.
Spruce Woods	36	1,000	....	....	....	....	....	....	666	34 25	Brandon.
Turtle Mountain	214	1,400	....	....	....	33,200	....	....	4,692	128 75	Brandon.
Riding Mountain	424	23,212	550	2,300	12,205	1,358,263	....	....	3,354	2,176 70	Dauphin.
Duck Mountain	248	14,638	2,550	11,900	15,818	812,349	....	....	1,126	1,217 37	Dauphin.
Rocky Mountain	203	161,323	26,685	31,930	28,714	1,014,250	60,000	40,250	1,993	1,108 65	Edmonton. Red Deer. Calgary. Lethbridge.
British Columbia Reserves	3	4,400	....	....	....	....	....	....	....	0 75	Kamloops.
Totals	1,622	820,343	119,785	166,530	165,252	3,335,463	60,000	40,250	17,885	5,051 80	

HAY PERMITS ISSUED, 1912-13.

Reserve.	No. of Permits.	Quantity cut.	Revenue.
		Tons.	$ cts.
Beaver Hills	3	30	4 50
Cypress Hills	24	636	75 70
Duck Mountain	15	145	22 00
Moose Mountain	24	635	70 00
Nisbet	1	3	2 00
Pines	6	66	9 10
Riding Mountain	52	1,039	111 40
Rocky Mountain	22	650	60 45
Spruce Woods	7	109	18 00
Turtle Mountain	2	45	5 50
British Columbia Reserves	3	60	7 50
Total	159	3,418	386 15

STATEMENT showing the quantity of Timber and Revenue received during the Fiscal year ending March 31, 1913, on License Timber Berths within Dominion Forest Reserves.

MANITOBA.

Reserve.	Berths.	Area.	Quantity Cut.		Revenue.		
			Lumber.	Logs Cut.	Royalty.	Rent.	Total Revenue.
		Sq. M.	Ft. B. M.	Logs.	$ cts.	$ cts.	$ cts.
Riding Mountain.	6	64.00	500,000	47,575	87 13	320 00	407 13
Duck Mountain..	11	110.78	....	83,825	....	553 94	553 94
	17	174.78	500,000	131,400	87 13	873 94	961 07

ALBERTA.

Reserve.	Berths.	Area.	Lumber.	Logs Cut.	Royalty.	Rent.	Total Revenue.
Rocky Mountain.	30	732.61	13,063,319	16,608 fence-posts 1,483,200 laths. 40,739 ry. ties. 14,960 lineal feet piling 81,663 logs 59⅓ cords cordwood.	6,231 26	3,667 26	9,898 52

BRITISH COLUMBIA.

Reserve.	Berths.	Area.	Lumber.	Logs Cut.	Royalty.	Rent.	Total Revenue.
	Pt. 1 berth	38.50	....	....	....	192 50	192 50
Total for Dominion Forest Reserves..........		945.89	13,563,319	....	6,318 39	4,733 70	11,052 09

License Berths in Manitoba Forest Reserves.

Duck Mountain Reserve.

No. of Berth.	Area.	Quantity Cut.		Other Products.	Revenue.	
		Lumber.	Logs.		Royalty.	Rent.
	Sq. Mi.	Feet B. M.			$ cts.	$ cts.
14	3.30	...	...	...	...	16 50
15	4.53	...	...	...	...	22 65
23	6.67	...	...	...	...	33 35
25	2.49	...	...	...	...	12 45
25a	10.81	...	...	...	...	54 05
26a	5.16	...	...	...	...	25 84
48	4.50	...	...	...	...	22 50
Pt. 571a	...	(See Riding Mountain all included in Riding Mountain) ...				
742	6.24	...	...	...	...	31 20
986	50.00	...	60,000	...	...	250 00
1,089	2.25	...	...	...	...	11 25
1,120	14.83	...	23,825	...	...	74 15
...	110.78	...	83,825	...	...	553 94
551d	18.00	...	...	...	...	90 00
571	4.75	...	...	...	...	23 75
Pt. 571a	23.25	...	36,175	...	...	116 25
575	18.00	500,000	11,400	...	87 13	90 00
...	64.00	500,000	47,575	...	87 13	320 00

License Berths in Alberta Forest Reserves.

Rocky Mountains Forest Reserve.

No. of Berth.	Area.	Quantity.			Revenue.	
		Lumber.	Logs.	Other Products.	Royalty.	Rent.
	Sq. Mi.	Feet B. M.			$ cts.	$ cts.
36	45.33	...	...	475 lin. ft. dry mining timber...	...	225 85
36a	47.92	3,676,415	32,434	59$\frac{1}{3}$ cords of cordwood ...	2,104 61	239 60
80	47.34	...	...	...	...	236 70
179	44.68	...	...	...	...	223 40
253	11.17	2,624,438	45,980	1,444,150 laths...	1,491 78	55 85
292	20.58	...	...	...	...	102 90
569	21.33	46,297*	3,249	...	...	106 66
579	33.31	...	...	...	55 49	166 55
594	6.13	...	...	...	...	30 65
606	3.00	...	...	...	...	15 00
Permit 1,098	37.45	...	...	...	...	187 25
1,099	45.20	...	...	40,739 ry. ties... 14,960 lin. ft. piling	795 86	226 00
1,154	17.34	...	...	...	...	86 70

License Berths in Alberta Forest Reserves—Continued.

		Rocky Mountains Forest Reserve.				
		Quantity.			Revenue.	
No. of Berth.	Area.	Lumber.	Logs.	Other products.	Royalty.	Rent.
	Sq. Mi.	Feet B. M.			$ cts	$ cts.
1,115	17.25					86 25
1,118	88.95					444 75
1,122	82.17					410 85
1,124	1.70			108 fence-posts	185 07	8 50
1,157	6.93	368,459				34 65
Rocky Mountain Park						
1,219	40.61					203 05
1,246	3.50					17 50
1,292	10.31	5,853,396*		13,143 fence-posts.. 379,050 laths	1,190 81	56 55
1,302	7.07					35 35
1,327	6.91					34 55
1,384	8.23	494,324		3,357 fence-posts..	408 27	41 15
1,393	10.24					51 20
1.412	23.02					115 10
1,413	21.50					107 50
1,414	7.50					37 50
1,415	6.68					33 40
1,429	9.26					46 30
	732.61	13,063,329	81,663	†	6,231 26	3,667 26

*Fire-killed timber; of the total of 13,063,319 feet, board measure, 5,899,693 feet were fire-killed.

†The total of other products comprises 1,823,200 laths, 40,739 railway ties, 14,960 feetlineal of piling, 16,608 fence-posts and 59⅓ cords and cordwood.

License Berths in British Columbia Forest Reserves.

Pt. 42)	38.50					192 50

APPENDIX No. 1.

REPORT OF THE CHIEF OF THE TREE-PLANTING DIVISION.

Forestry Branch,
Indian Head, Sask., March 31, 1913.

R. H. Campbell, Esq.,
Director of Forestry,
Ottawa.

Sir,—I have the honour to submit herewith my 13th annual report, dating from March 31, 1912.

General conditions throughout the prairie provinces affecting tree growth have during the past season again been very favourable. In most sections there has been

an abundance of rainfall, rather above the normal, and all reports relative to the growth of farm plantations are most encouraging. Beyond this there is nothing of particular importance to note in regard to the general progress of the outside tree-planting work. The interest in tree-planting and home beautifying is continuing to increase throughout the West as indicated by the establishment of new nurseries, the comparatively large appropriations now being set aside by the larger towns and cities for parks work, and especially by the Canadian Pacific Railway Company for planting on their own property, and also to supply stock to farmers residing on land purchased from the company.

INSPECTION WORK.

Two new inspectors were engaged for the summer season, namely, Messrs. B. R. Morton and Wm. Kynoch, both of the Faculty of Forestry of the University of Toronto. Mr. J. N. B. McDonald, who had been on the staff for a number of years, resigned early in the spring to take up commercial nursery work in Alberta.

The following tables give, in summary form, (1) the districts covered in 1912 by each inspector, together with details of the distribution, and (2) a classification of the applicants on the 1913 list:—

TABLE 1.

INSPECTORS' DISTRICTS AND DETAILS OF ALLOTMENT OF TREES

Inspector.	District.	Number of men on list.	Number of trees. received	Number of trees allotted.	Average number of trees per applicant.
W. Guiton......	Main line C. P. R., Fleming to Maple Creek......	1,042	524	464,102	885
A. P. Stevenson.	All railway lines in Manitoba......	663	314	269,375	857
A. Mackintosh..	Eastern Sask. G.T.R., Yorkton Branch, Pheasant Hills Branch C.P.R..........	694	192	205,975	1,072
W. MacDonald..	Southeastern Sask. Soo line, &c....	904	468	456,100	974
James Kay......	Pheasant Hills Branch (west of Saskatoon) G. T. R. Goose Lake Branch........	1,064	530	580,650	1,095
G. Kennedy....	Regina Branch C.N.R., main line C.N.R. Sask. Outlook Branch....	1,017	487	508,000	1,043
J. Cowie..	Southern Alberta, North to main line, C.P.R	885	445	440,300	989
B. Morton	Railway lines Northwestern Alberta	710	261	287,600	1,101
W. Kynoch.. ..	Railway lines Northern Alberta ...	638	298	237,850	798
	Totals.	7,617	3,519	3,449,952	average 980

NOTE.—Above figures will be somewhat altered on account of supplementary forms to be added to shipping list.

TABLE 2.

TABLE OF CLASSIFICATION FOR 1913 DISTRIBUTION.

Class.	Number.
A—1. Number of applicants on inspection list	7,617
2. " " who have received trees	4,820
3. " " " not "	2,797
B—1. Number of applicants receiving trees in 1913	3,519
2. Old " " "	2,105
3. New " " "	1,414
C—1. Number of applicants not receiving trees	4.098
2. Old " " "	2,715
3. New " " "	1,383

NOTE.—There will be a slight alteration of the above figures before the 1913 shipping list is completed, on account of supplementary forms not yet received.

It will be noticed that about fifty per cent of the applicants on the inspectors' lists are not to receive trees, that is, of a total of 7,617, only 3,519 are to be supplied this spring. Of the remaining 4,098, 2,715 are men who have received trees from us for two or more years in succession and are not now entitled to further supplies as long as the demand from new applicants is so great. To 1,383 new applicants trees were not granted for various reasons, the chief being lack of proper preparation or the fact of their ground not being arranged suitably in relation to buildings.

District inspected by W. B. Guiton.—1912 plantations are reported in good condition, 96 per cent of cuttings and 85 per cent seedlings living. A few failures due to neglect were found chiefly in the newer districts west of Moosejaw. No winter-killing in this district. Plantations set previous to 1911 have made sufficient growth, so that cultivation is no longer necessary.

District covered by Angus Mackintosh.—1912 plantations in good condition. Failures chiefly in cuttings, probably about 30 per cent loss. Older plantations have made splendid growth, some being now 14 to 20 feet high. In some few cases (about 20) plantations have failed. In practically all these cases farms have changed hands and the new owners neglected the trees. Such evergreens as were seen, planted 1912, were doing splendidly. Season was very favourable for tree growth.

District covered by Wm. Macdonald.—1912 plantations in splendid condition. Loss of trees about 10 per cent. Plantations of 1911 and 1910 in good growing condition. In a few cases plantations on very heavy soil had been retarded by too much moisture. In cases where plantations are now well grown farmers are taking cuttings and seed to extend their plantings. Evergreens planted 1912 very good, practically no failures.

District covered by James Kay.—1912 plantations fair, lack of knowledge main causes for failure. Ninety-five per cent of trees living, 1911 plantations and previous ones suffered more or less from frost during fall and spring of 1910 and 1911. Extremely hot in June, but more than normal rainfall during rest of season. Some plantations set back by hail in 1911.

District covered by Geo. Kennedy.—1912 plantations good, 95 per cent living, largest per cent of failures in cottonwood seedlings. Plantations of 1911 in good condition, average height 5 feet. Plantings of 1910 and earlier average 15 to 17 feet.

Ash in the older plantations is now growing vigorously. June very hot but no bad effects noticed. Some extensions to plantations in this district have been made from cuttings taken from the older trees.

District covered by Jas. Cowie.—Latter part of June very hot, but no bad effects noticed except where preparation had been indifferent or where there had been lack of cultivation after planting. Planting of 1911 made good growth and wintered well except along Calgary line, Canadian Pacific Railway, where instances of maple, cottonwood and willow killing back were noticed, 1910 and previous plantations showing up well. Greatest loss from winter-killing between Calgary and Cochrane. All evergreens of 1912 planting were most successful.

District covered by Wm. Kynoch.—1912 plantations on the whole in good condition, no serious damage from dry hot spell in latter part of June, cottonwoods suffering most. Eighty-five per cent of trees in 1911 plantations growing well. Plantings of 1910 suffered badly from severe drought in that season, clearly showing importance of thorough preparation. All previous plantations in good shape, except a few which had been neglected. Ninety-five per cent of evergreens planted 1912 living and doing well. This class of stock is very much appreciated.

District covered by B. R. Morton.—Ninety-five per cent of 1912 trees growing. All older plantations in good condition. Some failures in cuttings, due principally to shallow planting. In few cases cuttings were destroyed by cutworm, especially noticed when planting was done on old garden ground. Some damage from frost noticed in all Alberta plantations, but nowhere serious except in the vicinity of Gleichen, where large cottonwoods had been killed outright, possibly due partly to late cultivation in summer and too much irrigation during late growing season. There seems to be a tendency to stop cultivation just a little too soon, that is before the older plantations are in condition to be left alone. As a consequence grass and weeds get a foothold and retard the growth of the trees.

OFFICE WORK.

	April 1st, 1911, to March 31st, 1912.	April 1st, 1912 to March 31st, 1913.
No. planting plans prepared	3,004	3,000.
No. pieces mail received	12,249	14,161 (includes 3,000.
No. pieces mail sent out	20,382	21,466 (plans franked).
No. new files added	2,696	2,943.

Note—This does not include bulletins, these being sent out from the office at Ottawa.

EXHIBITS.

The usual exhibits were prepared for the summer fairs at Calgary and Brandon, and as in past seasons these proved to be of considerable interest to a very large number of the visitors.

LECTURES.

Mr. A. P. Stevenson addressed a number of meetings in Saskatchewan during the latter part of November and December. These meetings are held throughout the province in connection with the extension work of the Provincial College of Agriculture.

NURSERY WORK.

For actual nursery work the past season proved to be one of the best we have yet experienced. The growth of all stock was particularly strong and germination of seed good, resulting in very even stands. No trouble was encountered this spring from late frosts which so frequently injure many of the young seedlings just at their tenderest stage.

Owing to the unusually early freeze-up in the fall of 1911 practically no seed was sown that fall. Ash seed was put in as early as possible last spring, about April 7, and fortunately germinated very well, but the seedlings did not reach as large a size as usual when the seed is sown in the fall.

The following areas were devoted to the different kinds of trees:—

Broad-leaved—		
Maple, 1 year	21 acres.	
Ash, 2 year	20 acres.	
Ash, 1 year	21 acres.	
Caragana, 1 year	3 acres.	
Willow, cutting stock	5 acres.	
Russian Poplar, cutting stock	2 acres.	
		72 acres.
Coniferous—		
Transplants	7 acres.	
Seed-beds	1 acre.	
		8 acres.
Total under nursery crops		80 acres.

The following quantities of stock are available for distribution this spring:—

Manitoba Maple, 1 year	1,363,500	
Green Ash, 2 years	1,613,750	
Russian Poplar Cuttings	293,250	
Red Willow Cuttings	291,625	
Acute-leaf Willow Cuttings	394,000	
Caragana, 1 year seedlings	119,375	
Norway Poplar Cuttings	6,000	
		4,081,500

Conifers for distribution or permanent planting:—

White Spruce, 5 years, transp.	14,678	
Lodgepole Pine, 4 years, transp.	31,389	
Jack Pine, 4 years, transp.	21,478	
Scotch Pine, 4 years, transp.	1,735	
Pinus Mughus, 4 years, transp.	60	
" ponderosa, 4 years, transp.	68	
" flexilis, 5 years, transp.	265	
Colorado Spruce, 5 years, transp.	1,573	
Norway Spruce *var. septentrionalis* 6 years, transp.	1,300	
Siberian Larch, 4 years, transp.	514	
Balsam Fir, 7 years, transp.	306	
		73,366
		4,154,866

A considerable quantity of this stock will be required for permanent planting on the Indian Head nursery and also for setting out on the new nursery station near Saskatoon.

COLLECTION OF SEED.

The past was not a particularly good seed-year for any varieties, elm and tamarack being practically unprocurable, while Manitoba maple was a very light crop. Green ash produced a fair crop. The following seed was collected:—

Broad-leaved—

Manitoba Maple, in Qu'Appelle Valley, near Indian Head	60½	2 bus. bags.
At Portage la Prairie	3	"
Near Medicine Hat	5	"
At Brandon	2	"
Total	70½	"
Green Ash, in Qu'Appelle Valley, near Indian Head	98	"
Caragana, on Nursery Station	585	lbs.
Lodgepole Pine, from Morley, Alta.	24½	"
Jack Pine	18½	"
Bull Pine, near Kamloops, B.C.	18½	"
White Spruce, Manitoba	18	"
Western Larch, near Cranbrook, B.C.	3	"

CONIFERS.

Seed-Beds.—Four thousand square feet of seed-beds were sown to Scotch Pine, Lodgepole Pine, Jack Pine, White Spruce and Tamarack. The seed-beds of 1911 show a good growth and a fine stand in almost all cases.

Transplants.—The following seedlings were moved last spring from the seed-beds to transplant rows:—

Scotch pine, 2-year seedlings	28,036
Lodgepole pine, 2-year seedlings	54,396
Jack pine, 2-year seedlings	21,384
White spruce, 3-year seedlings	154,867
Tamarack	53,464
Siberian larch, 2-year seedlings	4,000
Total	316,147

EVERGREEN DISTRIBUTION.

As stated in my last report a distribution of a limited number of evergreens was made last spring. Altogether we dug about 100,700 four and five year transplants of pine and spruce. The greater number of these were shipped out in consignments varying from 100 to 500 plants. Inquiries were made, during the latter part of the season, from all those who received these trees and from the reports returned the results of the first planting have been extremely successful. In the majority of cases the applicants report a loss of only from one to three per cent, and in no case has a loss of over five per cent been reported. Such a showing speaks well for the care which the planters must have bestowed on the handling of this stock and indicates that the farmers fully appreciate the value of the conifers.

Two hundred and fifty-three shipments were sent out; 25 of these went to Alberta, 158 to Saskatchewan and 20 to Manitoba.

This distribution will be continued again this spring, and it is hoped that equally good results will be secured.

PERMANENT PLANTATIONS.

The established permanent plantations continue to make good progress; already some of the earlier plantings of the quicker-growing varieties, such as Russian poplar and cottonwood, clearly show the feasibility of the prairie farmer growing his own fuel in a very short time if he so desires. After seven season's growth on the nursery a very fair quantity and quality of fuel could be cut out of the poplar and cottonwood plantations. The cottonwood, however, on the nursery has clearly shown the unsuitability for planting in pure stands. The growth is far too open and permits of too rank growth of weeds and grass. When planted in equal mixture with maple, however, the results are excellent.

The older plantings of conifers are now showing more noticeable results—particularly the tamarack and Scotch pine. Some small plantings of Siberian larch have been most successful, and indicate that this variety may prove of considerable value for prairie planting.

Some eight and one-half acres were added to the permanent plantings this spring, viz.:—

Siberian larch and Maple..	2¼	acres.
Jack pine and Caragana	1¾	"
Lodgepole pine and Caragana	¾	"
White spruce and Caragana	1¼	"
Norway spruce (*Picea excelsa septentrionalis*) and maple..	1	"
Norway poplar and maple..	1½	"

ORNAMENTAL GROUNDS.

The hardy shrubs and herbaceous perennials made a good showing during the season, the lilac being particularly fine in the early summer. The annuals, as usual, provided an abundance of bloom, adding to the attractiveness of the grounds in the neighbourhood of the buildings.

GENERAL FARM WORK.

No new ground was broken up this season, as it was not practicable to handle a larger area than at present under cultivation with the available labour. As usual the necessary feed—oats and hay—was raised on the nursery, and some 55 acres summer-fallowed, besides the ploughing and cultivating required in the plantations and nursery plots.

NEW BOARDING HOUSE.

A new boarding house was erected and will be ready for occupation early this spring. This will give us accommodation for from ten to twelve additional men, which has been very badly needed during the past two seasons.

Respectfully submitted,

NORMAN N. ROSS,

Chief of Tree Planting Division.

APPENDIX No. 2.

REPORT OF DISTRICT INSPECTOR OF FOREST RESERVES FOR ALBERTA.

FORESTRY BRANCH,
CALGARY, March 31, 1913.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa, Ont.

SIR,—I have the honour to submit herewith my first annual report as district inspector of Dominion Forest Reserves for the Province of Alberta.

NAMES AND AREAS OF ADMINISTRATIVE UNITS.

There are three forest reserves in the Alberta inspection district, divided into seven administrative units. The names of these divisions, with the headquarters and area of each, are shown in the following table:—

TABLE 1.

ADMINISTRATIVE DIVISIONS OF THE FOREST RESERVES IN ALBERTA.

Forest.	Headquarters.	Acres.
Crowsnest	Pincher Creek, Alta	856,960
Bow River	Calgary, Alberta	1,998,360
Clearwater	Rocky Mountain House, Alberta.	2,460,800
Brazeau	Coal Spur, Alberta	2,506,880
Athabaska	Coal Spur "	1,696,640
Cooking Lake	Calgary, "	17,360
Cypress Hills	Calgary, "	99,840
		Total 9,690,840

In addition to this area a total of 1,690,080 acres of proposed extensions of the forest reserves in the district are also covered by the forest rangers, and are being administered in co-operation with the Dominion Land Office pending final action by Parliament on the recommendations.

These extensions are as follows:—

TABLE 2.

PROPOSED ADDITIONS TO DOMINION FOREST RESERVES IN THE ALBERTA INSPECTION DISTRICT.

Forest.		Area of Proposed Addition.
		Acres.
Crowsnest		126,560
Clearwater		228,480
Brazeau		580,480
Athabaska		754,560
Total		1,690,080

It is further proposed to make very large additions to the forest reserve area north of the Athabaska river, extending from the Lesser Slave lake to the Rocky Mountains and including a strip of rough, mountainous or hilly country which separates the agricultural region south of the Athabaska river from the agricultural region of the Peace River country. The examinations of this land are not yet completed and none of it is as yet under administration.

PERSONNEL.

There were employed during the year in the district office, in addition to the inspector, an accountant and one stenographer. On the reserves there was a total of 164 employees. The grades and total salaries of these employees are shown in the following table:—

TABLE 3.

TABLE OF EMPLOYEES ON RESERVES.

Title.	Number.	Salary.
		$ cts.
Supervisors	11	6,150 64
Forest Assistants	5	2,073 10
Forest Rangers	56	31,939 81
Clerks	6	1,728 12
Labourers	86	8,421 62
Total salaries		50,313 29

It should be noted, however, that during the course of the year there were numerous changes in the force, largely through resignations. Of the supervisors, five resigned and one was transferred. Four of the men who resigned accepted positions with the British Columbia Government and one went into private work. The maximum number of supervisors employed at any one time was four. Of the forest assistants, one resigned and two were promoted to supervisory positions. The maximum number of forest assistants employed at any time was three. Of the clerks two resigned. The maximum number of clerks employed at any one time time was three. Of the fifty-six forest rangers employed, twenty-four were employed for periods greater than nine months and thirty-two for periods of less than nine months.. The temporary labourers were practically all employed for periods of less than three months.

The total expenditure on the various forest reserves in the Alberta inspection district is shown in the table below. In this table the expenditure is also classified under the seven major accounts into which forest reserve expenditures were divided during the past fiscal year.

TABLE 4.

DISBURSEMENTS ON THE FOREST RESERVES OF THE ALBERTA INSPECTION DISTRICT.

Name of Forest or Office.	Salaries.	Expenses, Supplies, &c.	Buildings.	Telephones.	Trails and Fire Lines.	Fires.	Total expended.
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Alberta Inspection Office.	4,518 38	2,919 93	....	....	......	......	7,438 31
Athabaska	1,950 31	543 03	....	....	......	......	2,493 34
Clearwater	5,749 99	2.317 37	941 40	....	2,862 47	......	11,871 23
Crowsnest	10,659 49	2,469 91	1,630 63	5,156 89	1,768 55	58 95	21,744 42
Cypress Hills	3,284 39	486 45	15 90	....	320 51	......	4,107 25
Brazeau	9,240 26	2,983 47	1,519 00	642 37	1,985 27	......	16,370 37
Bow River	11,377 53	2,505 54	2,595 36	122 65	1,368 75	......	17,969 83
Cooking Lake	749 82	14 00	....	......	......	......	763 82
Grand totals	47,530 17	14,239 70	6,702 29	5,921 91	8,305 55	58 95	82,758 57

NOTE.—No expenditures were made on Account No. 6—Nurseries.

It is almost platitudinous to say that the success of any administrative organization depends primarily on the character of its personnel. The great fundamental problem in all organizations having a number of employees is the improvement of the standard of these employees. One need only recall the revolution which the efficiency expert has produced in modern industrial plants, the training school for employees maintained by so many of the more complex manufacturing and distributing industries, such as department stores or electrical supply factories, or the naval and military service schools which train the men to greater efficiency in their duties, to realize that everywhere, in all branches of industry, the need of special training is realized and active steps are being taken to provide it. In the work of forest protection and administration this need is in no degree less urgent. In European countries such as Germany, France and Switzerland, employees in the governmental forest services are required to undergo a long and painstaking course of training and to serve an apprenticeship extending over years. In the British India forest service men are trained for rangers and higher positions at the forest academy established and maintained since 1878 by the Imperial Government at Dehra Dun, where instruction is given both in English and in the vernacular. In the United States all employees of the service below the grade of Associate United States Forester are required to pass a rigid practical examination to qualify for employment and are then employed only in subordinate positions on probation and are required to demonstrate their fitness for permanent employment before being accepted by the service. Higher positions are filled only by promotion from lower grades, and promotion and increase in salary are given for merit alone. In Canada the fact that forest employees require any special qualifications or training has scarcely yet been realized. It might be well to call attention to the variety of employees in the service of the branch in this district alone. These include twelve distinct classes, as follows:—Forest Supervisors, Forest Assistants, Forest Rangers, Fire Guardians, Surveyors, Book-keepers, Stenographers, Carpenters, Cooks, Packers, Teamsters and Labourers. The qualifications for a cook, a surveyor, a stenographer or a carpenter are fairly well defined and can be readily appreciated by anyone. So also the forest assistant must have a technical training in forestry which involves a college course in the science as a general rule. But when we come to the forest ranger no such special requirements are realized. There is an almost total failure to appreciate that the work of a forest ranger is a highly specialized employment calling for a physical and mental equipment and training no less susceptible of

exact definition than is the profession of the surveyors, the cook or the book-keeper. Present-day methods of fire protection for standing timber are as much advanced over the methods of twenty years back as is the modern motor fire-truck an improvement over a bucket brigade. In similar measure have the requirements for the position of forest ranger advanced, although this has not been generally realized. No longer in those countries where forest fire protection has been developed along modern scientific and practical lines, is the forest ranger handed an axe and a badge and told to go out into the woods and prevent fires, any more than is the modern soldier given a war-club and told to go out and fight the enemy. The present-day ranger is a unit in a highly perfected organization. Fires are located for him by lookouts stationed on peaks selected with all the care of a topographer choosing triangulation stations, and equipped with range-finder, telescope, compass, maps and telephone. He receives his call to action by telephone, telegraph, wireless or heliograph. Instead of rushing out coatless and hatless to wage a single-handed fight with whatever tool is handiest, he considers his carefully drawn fire-plan, notes on his topographic map the lie of the land at the fire; decides upon the forces necessary for its control and the quickest way to get them on the ground, and then by means of his telephone he sends to that fire enough men and horses fully equipped with tools and provisions to smother it in its very incipiency in less time than the old-style ranger would have taken to gather together his grub-pile and saddle his horse. This is no idealistic picture, but an actual accomplishment fully developed and regularly employed by government and private owners of timberlands who control more timber several times over in the United States alone than stands in all Canada.

Moreover, fire protection does not by any means exhaust the duties of a ranger on the reserves. It is now generally realized that forest reserves are not created to take timber out of use but to put it to use under methods of scientific forest management that will insure its continuation as a permanent crop instead of permitting it to be exhausted at one cutting. If it is realized that it takes from four to six years of collegiate training to give men the fundamentals of this art of forestry it will be conceded that the forest ranger, upon whom falls the duty of carrying out the plans for scientific forest management, cannot be fitted for these duties unless he has been specially trained for them. It might well be asked, if a forest ranger is not simply a man who can ride a horse and swing an axe, *what his qualifications are.*

Putting aside the fact that rangers in the Canadian service are not infrequently unable to produce even these rudimentary qualifications, it might be answered that a forest ranger should be a man in perfectly sound physical condition, not too old to endure the hardships of wilderness travel—say, between 20 and 45—a first-class experienced woodsman, able to pack, cook, establish camps in a sanitary manner, and handle horses and boats. He should be either a practical lumberman acquainted with both the woods and the milling end of the business or a practical stockman, or both. He should have at least a common-school education. He should be able to make all kinds of compass surveys and prepare simple maps, to cruise timber, to lay out, estimate and construct trails, to erect forest telephone lines, install instruments and maintain them in working order, to plan, estimate and construct ordinary log and frame buildings, to handle crews of men, to deal tactfully with forest reserve users and mountain travellers and sportsmen. He should have some knowledge of elementary silviculture, know the common trees and forage plants of the region, know something of the habits of the fish and game animals and enough of forest insect and fungus diseases to recognize an infestation on sight. Needless to say, he should have had previous practical experience in fire-fighting before being placed in a responsible position involving the direction of such work. A ranger must also be able to write concise, intelligent reports on all lines of his work, to maintain the necessary office files and records and must be thoroughly conversant with all the various laws and regulations which he is called upon to enforce and administer;

being empowered to arrest without warrant, he must be familiar with the legal machinery of his province and know how to present and handle his case in court, to collect evidence, and establish his charge with competent testimony.

It may well be asked where men with such varied qualifications are to be obtained, and it must be admitted that they cannot be found in Canada to-day. Yet forestry as it is understood and practised by almost every civilized and progressive nation in the world, in Germany, France, Switzerland, Austria, India, South Africa, Japan and the United States (to cite only leaders in the movement) demands that men with these qualifications be secured to form the very foundation of a forest organization. The experience of foreign countries is enlightening. In Germany and other European states where forestry has been practised for generations, forest academies conducted to a large extent under government auspices prepare men for the grades that correspond to the forest ranger, and subsequent training at their own expense in government employment completes their preparation. In India, the Philippines and Japan, government training schools have been established. In the United States, training has been supplied to some extent by special ranger schools, of which quite a number exist in connection with state and other universities, and also by the government itself through its ability to select only suitable candidates, as determined by a qualifying civil service examination, and then train these men in its organization, under civil service rules that require a man to show satisfactory results or suffer dismissal.

In Canada, where we have one of the few large bodies of virgin timber left standing in the world to-day and where we have such great areas of land suited primarily for timber production and nothing else, we lag far behind other nations in our forest policy; but it is the boast of every Canadian, at least those of the west, that things are done in Canada while other nations are awaking to a realization of their desirability. In the creation of a forestry service commensurate with the dignity of Canada as the leading member in the group of overseas Dominions, an opportunity is offered to make good this claim. The method is comparatively simple. The fundamental requirement is to place the employees of the Branch under Civil Service rules, which will provide for employment only on a merit basis as determined by a suitable examination; for adequate salaries to attract qualified men, which need be little larger than are already being paid for unqualified men; for promotion only for efficiency and for tenure of office during good behaviour and satisfactory service. This is essential in order to establish the work on a permanent basis and attract men of character and ambition from employments where there is a ready market for their services to one where the market is of necessity restricted. The second requirement is the establishment of a training school where employees may be thoroughly equipped in those lines with which they are not already familiar. This need not be an elaborate or expensive institution. It should be located in a timbered region, preferably on one of the reserves, where the course of training can be strictly practical in character. At it, men who have had a reasonable previous experience in the fundamentals, and what is equally important, who are under some incentive to perfect themselves along the lines offered in the course of instruction, could undoubtedly be trained to meet our requirements in from six to nine months. The possession of suitable experience can readily be determined as already suggested under the Civil Service Commission through a qualifying examination. The incentive to secure further training can be supplied by requiring candidates for permanent employment to pass a second examination covering the more detailed qualifications which we cannot now expect candidates to possess, and attaching an increased salary to these advanced positions. In time similar schools in connection with the various colleges and universities would no doubt be established, as has been done in other countries and the government school might then be discontinued or merged with a neighbouring institition, if one existed. In spite of the unusual demand for labour of all kinds, the

extraordinarily high cost of living in the western provinces and the relatively small salaries offered by the government, no unusual difficulty has been experienced in getting satisfactory assistants except in the grades of forest ranger and forest supervisor. The difficulties encountered in securing good supervisors is largely technical of lack of suitable ranger material, because a first-class forest supervisor is, in the last analysis, simply a sublimated forest ranger plus a certain knowledge of technical forestry which almost any man with sufficient general education, intelligence and ambition can acquire. A supervisor must be a practical administrator, thoroughly experienced in all lines of forest reserve work and should preferably be selected by promotion from the ranger staff or from those forest assistants who have duly qualified themselves by practical field experience after graduation, and who possess the necessary executive ability. Given, therefore, an adequate staff of forest rangers selected on a basis of fitness and trained in the manner indicated, the development of a sufficient complement of supervisors and other higher officers would become one of simple evolution.

FIRES.

During the fiscal year ending March 31, 1913, the fire record in the Alberta Inspection District was unusually satisfactory. The number, causes, cost of control, and damage caused by fires in the district are shown in the tables given below. In these tables are shown, not only the fires which occurred within the boundaries of the Forest Reserves, but also all fires which occurred within the boundaries of proposed additions to the reserves, and a number of fires which were fought entirely outside of any Reserve or proposed addition, but which, if allowed to burn unchecked, might have threatened an adjacent Forest Reserve. The total number of fires which occurred inside the forest reserve boundaries was twenty-two, while eleven fires which occurred outside the boundaries were placd under control by the forest rangers.

TABLE 5.

TOTAL NUMBER OF FOREST FIRES REPORTED BY CLASSES ON EACH RESERVE.

Forest.	Class (A.)		Class (B).		Class (C).		Total.	
	Inside.	Outside.	Inside.	Outside.	Inside.	Outside.	Inside.	Outside.
Crowsnest	1	2	0	1	0	2	1	5
Bow River	0	0	0	0	1	0	1	0
Clearwater	0	1	0	0	1	1	1	2
Brazeau	15	0	0	2	3	1	18	3
Athabaska	0	0	0	0	0	0	0	0
Cooking Lake	0	C	0	0	0	0	0	0
Cypress Hills	1	1	0	0	0	0	1	1
Total	17	4	0	3	5	4	22	11

Note—Fires are classified as follows:

Class A.—Camp-fires and other small fires not covering more than a few square rods.

Class B.—Small forest fires extinguished without any extra help or expense and generally covering not more than five acres.

Class C.—Large fires requiring extra help and expense.

TABLE 6.

CAUSES OF ALL FIRES REPORTED.

Forest.	Ry. Construction.	Locomotives.	Clearing Land.	Camp Fires.	Lightning.	Dropping Match.	Unknown.	Total.
Crownest	0	2	0	0	1	1	2	6
Bow River	0	0	0	1	0	0	0	1
Clearwater	1	0	1	1	0	0	0	3
Brazeau	1	20	0	0	0	0	0	21
Athabaska	0	0	0	0	0	0	0	0
Cooking Lake	0	0	0	0	0	0	0	0
Cypress Hills	0	0	0	2	0	0	0	2
Total	2	22	1	4	1	1	2	33

TABLE 7.

EXPENDITURE FOR FIRE FIGHTING BY FORESTS EXCLUSIVE OF RANGER LABOUR.

Forest.	Temporary Labour.	Supplies, Transportation, etc.	Total Cost.	Values of Voluntary Assistance.
	$ cts.	$ cts.	$ cts.	$ cts.
Crowsnest	48 00	10 95	58 95	5 00
Bow River	....	....	....	150 00
Clearwater	....	....	....	345 00
Brazeau	....	....	....	395 00
Athabaska	....	....	....	....
Cooking Lake	....	....	....	....
Cypress Hills	....	....	....	....
Total	48 00	10 95	58 95	895 00

TABLE 8.

FIRES REPORTED FROM EACH FOREST SHOWING MONTH OF OCCURRENCE.

Forest.	May.		June.		July.		August.		Sept.		October.		Total.	
	In.	Out.	In.	Out.	In.	Out.	In.	Out.	In.	Out.	In.	Out.	In.	Out.
Crowsnest	0	1	1	2	0	0	0	1	0	0	0	1	1	5
Bow River	1	0	0	0	0	0	0	0	0	0	0	0	1	
Clearwater	1	2	0	0	0	0	0	0	0	0	0	0	1	2
Brazeau	1	2	0	1	0	0	0	0	17	0	0	0	18	3
Athabaska	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooking Lake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cypress Hills	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	3	5	1	3	0	0	0	1	17	0	0	1	21	10

TABLE 9.

DAMAGE CAUSED BY FIRES ON EACH FOREST.

Forest.	Area of Reserved Land.	Area of Unreserved Land.	Damage to Timber or Reproduction on Reserved Land.			
			Timber Destroyed or Damaged.		Value of Reproduction Destroyed.	Total.
			Quantity.	Value.		
	Ac.		M. Ft. B.M.	$ cts.	$ cts.	$ cts.
Crowsnest	0	17	0	0 00	0 00	
Bow River	400	0	10	30 00	220 00	250 00
Clearwater	170	70	14	21 00	800 00	821 00
Brazeau	135	132	0	0 00	150 00	150 00
Athabaska	0	0	0	0 00	0 00	0 00
Cooking Lake	0	0	0	0 00	0 00	0 00
Cypress Hills	0	0	0	0 00	0 00	0 00
Total	705	219	24	51 00	1,170 00	1,221 00

A number of interesting points are brought out by a consideration of these tables. It will be noted, for instance, in Table No. V, that fifteen of the Class 'A' fires occurred on the Brazeau Forest Reserve. Table No. VIII indicates that all these fires occurred in the month of September. The fifteen Class 'A' fires, together with one Class 'C" fire and one Class 'B' fire, were all started on the Brazeau Forest Reserve on the same day by the one locomotive operated by Phelon & Shirley, contractors for the Grand Trunk Pacific. It was found upon examination that this locomotive was not equipped with a spark-arrester, and upon its being immediately so equipped the starting of fires from this source was eliminated. All these fifteen Class 'A' fires were set within an area of not more than a square mile, and many of them did not attain a size larger than a few square feet, being extinguished almost at once.

A consideration of Table VI shows that over 75 per cent of all the fires reported last year were caused by the railways. The total number of such fires was twenty-four, of which seventeen were Class 'A', one Class 'B' and six Class 'C.' The railways accounted for six out of the nine Class 'C' fires which occurred. Sixteen of the railway fires were on the line of the Grand Trunk Pacific, one on the Canadian Northern Western and two on the Crowsnest branch of the Canadian Pacific railway. None of these roads were at the time complying with the order of the Board of Railway Commissioners relative to fire patrol.

It will be noted from a consideration of Table IX that the largest fire occurred on the Bow River Forest Reserve. This fire, which covered 400 acres, started from an over-heated stove in the camp of a log-driving crew employed by the Great West Lumber Co., on the Red Deer river. It occurred in the month of May and was put under control by the employees of the company at no expense to the government. This fire was confined exclusively to new slash, which accounts for the comparatively small damage to reproduction. The fire causing the greatest damage was that which occurred on the Clearwater early in the month of May, before the reserve was placed under administration. This fire got a good headway in slash made by tie contractors for the Canadian Northern Western railway and burnt over about 170 acres, part of which was timbered and part covered with a good growth of reproduction. On the Brazeau the small damage caused by the Class 'C' fires is accounted for by the fact that these fires were confined almost exclusively to denuded areas or grass-lands.

It will be noted from a consideration of Table VII that the expenditure made by the government for fire-fighting was very small. In almost every case the person responsible for the fire was known and was compelled to place the fire under control or did so voluntarily.

Table VIII shows very clearly the character of the season. It will be noted that of the thirty-three fires reported twenty-five occurred during the months of May and September, while only five occurred during June and August, there being no fires at all during July. The month of May last year was comparatively dry, and the first half of June was exceptionally dry. From about the middle of June until well along into September frequent rains occurred, especially in that portion of the forest reserve lying between the Bow river and the Athabaska but north of the Athabaska river the season was comparatively dry, becoming extremely dry in the far northern end of the Reserve, although no fires occurred in this portion of the mountains. Very large fires, however, are reported to have occurred along the Peace river, the smoke from these fires obscuring the landscape in the Athabaska Forest Reserve during several weeks in Septeember.

It is impossible from a consideration of the past season's fire-record to arrive at any conclusion in regard to the efficiency of the men employed on the various forest reserves, because the season was so remarkably favourable that no real test of efficiency was afforded. A much better opportunity was afforded to test the ability of the organization to take advantage of the favourable weather conditions which prevailed to promote the general development of the forest reserves along fire-protective lines.

It will be readily understood that in a region where distances are so great and labour so scarce there is little possibility of adjusting the forest-protective force to the character of the season except in the most general way. It is practically necessary to employ a certain number of men early in the season and maintain them, under pay for a period of about six months, regardless of the character of the weather conditions during that period. When it is realized that it takes some of these men a week or ten days of hard travelling to reach their stations from the railway, the impracticability of taking on and laying off men according to the season becomes readily apparent. At the same time it is felt to be the duty of any fire protective organization not only to prevent and extinguish fires during season of employment, but also, when conditions are favourable, to improve and extend the facilities for fire prevention and suppression. Such facilities consist very largely of permanent improvements in the nature of roads, trails, bridges, cabins, &c. This feature of the work will be further dealt with under the heading of Permanent Improvements, because it is felt to be the only means by which the Forest Reserves can be placed in a condition to be successfully protected from fire within a reasonable time and at a reasonable expense.

The fire-protection work on the Forest Reserve forms the basis of the entire administration, and at the present time can be considered the most important work that we are undertaking. The general organization has already been described in previous reports, but it might be well to note briefly the developments during the past year. The entire Forest Reserve area in this district has been divided into seven administrative units as indicated in Table 1. These units have been placed under the charge of Forest Supervisors, who have subdivided them into fire-protection districts placing a ranger in charge of each district. The Districts are laid out on topographic lines, consideration being given to the fire danger, the timber and the facilities for communication within the district. They naturally vary much in size, the smallest being about 25,000 acres and the largest 500,000 acres. The average for the entire district last year was 211,000 acres per ranger. If our personnel was up to a high standard of efficiency, and the permanent improvements needed on the forest reserves were completed, I believe that this average would be satisfactory. I do not mean that entire immunity from fire could be promised with an intensity of fire patrol such as we had during the past year, but in considering this question the fact must be remembered

that the Rocky Mountains are not covered with mature timber of any great value and the danger of fire starting is not by any means excessive. It is obvious that an area of forest land which supports only a growth of reproduction of which little is over forty years of age, does not have the same value as an equal area of land in merchantable timber. This reproduction, of course, has a value which justifies a certain expenditure in order to protect it from fire, but no one can argue that this expenditure should be as great as in the case of merchantable timber, nor that the fire protective force would be justified in attempting to restrict the area burnt over under a given set of conditions to as small an acreage as in the case of merchantable timber. We are, therefore, not justified in attempting to provide absolute immunity from fire-damage in the Rocky Mountain Forest Reserve, but only such a degree of protection as is justified by the value of the resources under our charge.

Considering, therefore, the condition of our personnel and the lack of improvements and facilities for communication within the reserves, I feel that the average area entrusted to each ranger is too great, and that it should be reduced to not more than 150,000 acres. This will involve a material increase in the force, even to guarantee a reasonable security from destructive fires. In addition to having a special force of fire rangers during the dangerous season, the other work on the reserves should be so planned as to supplement the work of the fire-patrolmen.

Temporary crews, such as road and trail gangs or survey crews, should be employed as much as possible only during the most dangerous season, and should be distributed throughout the reserve so that they may act as a reserve force in cases of emergency.

As regards the existing conditions on the Rocky Mountains Forest Reserve as a result of previous fires, former publications of both the Forestry Branch and the Geological Survey have described these conditions in more or less detail. My inspection work has now enabled me to cover in considerable detail almost the entire reserve from the international boundary to the Athabaska river. Everywhere it is found that fires have caused enormous destruction of merchantable timber within the past fifty years. The mature stands of merchantable size now constitute only small isolated islands of green timber in a vast area of denuded land or young reproduction. Various estimates of the amount of land in the reserve now bearing merchantable timber have been given, running as high as 25 per cent for that portion south of the Red Deer river. I believe that this estimate is approximately correct, but the destruction by fire has been far more widespread north of the Red Deer than it has been to the south, so that, in my opinion, not more than 10 per cent of the entire reserve area south of the Athakaska river now bears timber of merchantable size and quality.

The most important step in the organization of the fire-protective work during the past year has beeen the preparation of fire plans for each of the forest reserves. Since adequate fire protection is fundamental in the practice of Forestry, too much emphasis upon securing such protection can scarcely be placed at the beginning of such administration. The purpose of a fire plan is to put in clear-cut concrete form all the information available with regard to the fire danger, the supply of men available for fire fighting, the means of communication within the reserve, the facilities for securing assistance from distant points if necessary, and numerous other kinds of information which are ordinarily carried in the heads of those officers charged with work of this character, but which do not form a part of the permanent records of the organization. The Fire Plan not only serves the purpose of making available permanently all information of value in regard to the fire situation within and adjacent to the forest reserve, but it also serves the very valuable purpose of bringing to the attention of forest officers themselves the location of areas of particular danger or portions of the forest reserve which present unusual obstacles to ready access. Naturally the degree of success with which a fire plan can be prepared depends to a considerable extent upon the accuracy and detail of the acquaintance of the officer

preparing the plan with the country under consideration. Fire plans for all the reserves in the Rocky Mountains have been prepared for several years, but will have to undergo constant revision for several years before they assume definite and more or less permanent form. It might be pointed out that work of this kind has been carried out on many of the national forests of the United States where the preparation of definite plans of action in the case of fire emergency has been carried to such a state of perfection that it is readily possible for a ranger of ordinary intelligence, even though wholly unacquainted with the country, to take hold of a ranger district and merely from the available data in the form of the District Fire Plan have at once at his finger ends information in regard to the country and the fire-fighting and fire-locating facilities which, without the plan, would ordinarily take months, or even years, of personal study of conditions to secure.

PERMANENT IMPROVEMENTS.

The work of extending the roads and trails, constructing cabins for the use of forest officers and in other ways improving the facilities for rapid communication within the forest reserves has been continued throughout the year. A total of $27,754.91 has been expended on work of this character, of which $6,825.16 was for labour performed by the forest rangers.

For very evident reasons, the work of constructing permanent improvements on the reserves during the past year has not been wholly satisfactory to me. When I took charge of the district at the beginning of the last working season, I found absolutely no preparation for work of this character whatever, and no organization or system in existence whereby the essential preparatory work could be accomplished At the same time, the pressure to place the reserves on a better basis for protection—a very natural result of the disastrous fire season of 1910—was great. Moreover, fairly ample funds were available for a season's work, and with little danger from fire, owing to the favourable season, it seemed highly desirable to make a start on work of this character, even without the careful preparation that I would ordinarily have required. To handle this work on a thoroughly sound basis, it is first necessary that a reconnaissance be made of each reserve by a qualified forester to determine the proper division into ranger districts as indicated by topography, timber and fire-hazard, the logical and practical site for the district head-quarters, the routes which the primary and secondary trails must follow, the alignment of the telephone system, the possibilities of establishing a lookout system for fire location and the special improvements, such as bridges, ferries, roads, etc., that are needed. If an accurate topographic map is available, this work is very greatly simplified. We had no such maps, in fact, no maps of any value whatever, and, therefore, no opportunity to lay out a general plan in advance. Even had we had the general plan as a foundation for handling work on a business-like basis, we should then have made detailed examinations of the most urgent projects, prepared plans and estimates for the trails, cabins, bridges, etc., and determined the location and status of the proposed building sites by suitable surveys and search of land office records, before undertaking any construction. All this, however, would have consumed a great amount of time, in fact, considering that even before we could begin to get this data we had to hire and organize a personnel, I did not feel that we could adopt this procedure and get any work done at all. I, therefore, adopted the system of approving such projects as seemed, from the data at hand, least likely to be wrong, and spent about two-thirds of my time in the mountains with the supervisors assisting them to select suitable projects. That some mistakes would occur was inevitable, but on the whole we were fairly successful in avoiding the establishment of monuments to our lack of adequate preparation. I find that out of 56 completed and 28 uncompleted projects, or a total of 84 projects undertaken, only four show the results of lack of proper planning in faulty construction or unreasonably excessive cost. Meanwhile, however, we have been securing the information needed to handle the permanent improvement work in

a systematic manner, deciding upon standards and specifications and developing a system of procedure, and during the next fiscal year will confine our work largely to projects which have been given adequate consideration and which must be built according to definite standards established by the district inspector.

In the following tables I have shown the improvements made on each of the forest reserves with the itemized cost of the same. The first set of tables shows those projects which are completed. The second set is those projects which are incomplete or which are merely preparatory for next year's work. Here also I have shown all the maintenance and repair work which cannot be classified as specific projects.

TABLES OF COMPLETED IMPROVEMENT PROJECTS.

TABLE 10.

CROWSNEST FOREST.

Class of Improvement	Length.	Number.	Labour.	Cost. Materials.	Tools.	Subsistence.	Transportation.	Miscellaneous.	Memo Charge Ranger Labour.	Total.	Average per mile per Unit.
	Miles.		$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Roads	¼	..	198 00	32 00	.... ..	64 13	...	......	44 40	338 53	......
Trails (Secondary)	50	..	293 00	....	....	116 88	10 00	.... .	250 15	670 03	13 46
Telephone Lines	51	..	2,226 41	862 18	326 28	745 03	652 32	115 15	440 10	5,367 47	105 25
Ranger Stations	....	1	123 42	500 75	4 45	127 86	115 00	......	174 97	1,046 45	.....
Barns	....	2	68 60	73 99	......	31 67	......	.....	47 32	221 58	110 79
Cabins	....	1	26 00	20 30	......	13 00	26 50	.....	84 70	170 50	.....
Bridges	....	5	435 67	10 75	.. ...	184 17	94 00	......	151 30	875 89	175 18
Totals	....	..	3,371 10	1,499 97	330 73	1,282 74	897 82	115 15	1,192 94	8,690 45	.....

TABLE 11.

BOW RIVER FOREST.

Class of Improvement.	Length.	Number.	Labour.	Cost. Materials.	Tools.	Subsistence.	Transportation.	Miscellaneous.	Memo Charge Ranger Labour.	Total.	Average per mile per Unit.
	Miles.		$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Trails, Secondary	123	..	1,061 45	....	.....	111 55	13 00	.....	1,056 70	2,242 70	18 23
Trails, Standard	18	..	... ...	.. ...	. .	....	.. ..	.....	404 66	404 66	22 48
Cabins	....	3	150 24	55 99	....	....	59 00	......	107 38	372 61	124 20
Ranger Stations	....	1	313 12	456 73	......	88 50	124 72	... .	283 57	1,266 64	.....
Barns	....	2	228 50	120 02	......	84 75	64 12	......	312 08	809 47	404 73
Bridges	....	1	84 00	12 00	.....	... .	......	.... .	102 45	198 45	... ..
Totals	....	..	1,837 31	644 74	.....	284 80	260 84	.....	2,266 84	5,294 53	......

TABLE 12.

CLEARWATER FOREST.

Class of Improvement.	Length.	Number.	Cost. Labour.	Materials	Tools.	Subsistence.	Trans-portation.	Miscellaneous.	Memo charge Ranger labour	Total.	Average per MileperUnit.
	Miles.		$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Roads..........	7	..	544 75	....	8 10	65 55	....	....	75 20	693 60	99 09
Trails (Standard)	34	..	1,020 62	....	20 95	267 21	....	....	388 16	1,696 94	49 91
Trails (Secondary)...	42	..	74 25	....	.....	....	....	....	174 99	249 24	5 93
Fence (Pasture).	.....	..	....	....	. ...	..... .	....	....	....	... ...	....
Cabins.........	......	4	308 75	124 60	.....	... .	227 96	....	592 70	1,254 01	313 50
Totals......	......	4	1,948 37	124 60	29 05	332 76	227 96	....	1,231 05	3,893 79	....

TABLE 13.

BRAZEAU FOREST

Class of Improvement.	Length.	Number.	Cost. Labour.	Materials.	Tools.	Subsistence.	Trans-portation.	Miscellaneous.	Memo charge Ranger labour	Total.	Average per Unit per Mile
	Miles.		$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Trails....	60	.	1,085 75	72 95	23 25	455 25	88 32	259 75	....	1,985 27	33 09
Cabins..........	... ..	5	234 85	860 27	. ....	166 07	84 25	33 50	715 36	2,094 30	418 86
Barns	.....	4	... .	91 90	4 65	50 46	0 95	....	454 47	602 43	150 61
Lookout Statn's.	......	1	....	1 35	......	....	....	... .	26 96	28 31	28 31
Totals	.....	..	1,320 60	1,026 47	27 90	671 78	173 52	293 25	1,196 79	4,710 31	....

TABLE 14.

CYPRESS HILLS.

Class of Improvement.	Length Furrow.	Number.	Cost. Labour.	Material.	Tools.	Subsistence.	Trans-portation.	Miscellaneous.	Memo charge Ranger labour	Total.	Average per furrow per mile.
	Miles.		$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Fire-guards....	330·5	..	304 11	....	......	....	....	....	....	304 11	0 92
Totals ...	330·5	..	304 11	....	......	....	....	....	....	304 11	0 92

TABLES OF UNCOMPLETED IMPROVEMENT PROJECTS.

TABLE 15.

Improvement Project.	Length.	No.	Cost Ranger Labour.	Cost exclusive of RangerLabour	Total Cost.
	Miles.		$ cts.	$ cts.	$ cts.
Roads..........	7¼	...	119 60	912 53	1,032 13
Trails (standard)....	112	....	792 82	3,294 05	4,086 87
Trails (secondary)........	215	....	1,481 84	1,680 13	3,161 97
Telephone Lines..........	51	....	440 10	4,927 37	5,367 47
District Ranger Stations..........	....	2	458 54	1,854 55	2,313 09
Ranger Cabins.	....	13	1,500 14	3,391 28	3,891 42
Barns	....	8	813 87	819 61	1,633 48
Bridges..........	....	6	253 75	820 59	1,074 34
Lookouts	....	1	26 96	1 35	28 31
Fire-guards..........	330.5	....	....	304 11	304 11
Totals..........	....	....	5,887 62	17,006 57	22,893 19

TABLE 16.

CROWSNEST FOREST.

Project.	Length.	No.	Cost.	Ranger Labour	Total.
	Miles.		$ cts.	$ cts.	$ cts.
Trail Maintenance..........	168	....	397 02	264 64	661 66
Cabins..........	....	2	271 06	101 04	372 10
Fire-line Maintenance..........	3	....	29 00	....	29 00
Boundary Marking.	17	....	50 50	....	50 50
Purchase of Fire Tools..........	......	....	177 18	....	177 18
Telephone Supplies..........	12	....	197 00	....	197 00
Repairs to Cache..........	......	1	14 20	....	14 20
Miscellaneous..........	... .	....	50 13	....	50 13
Total..........	....	...	1,186 09	365 68	1,551 77

TABLE 17.

BOW RIVER FOREST.

Project.	Length.	No.	Cost.	Ranger Labour	Total.
	Miles.		$ cts.	$ cts.	$ cts.
Trail Maintenance	152	....	......	473 49	473 49
Cabins	....	5	777 04	44 00	821 04
Fences	....	2	....	54 37	54 37
Telephone Supplies	10	....	122 65	....	122 65
Miscellaneous	....	....	64 85	....	64 85
Total	162	7	964 54	571 86	1,536 40

TABLE 18.

BRAZEAU FOREST.

Project.	Length.	Number.	Cost.	Ranger Labour.	Total Cost.
	Miles.		$ cts.		$ cts.
Telephone supplies	40	....	642 37	....	642 37
Total	40	....	642 37	....	642 37

TABLE 19.

CLEARWATER FOREST.

Project.	Length.	Number.	Cost.	Ranger Labour.	Total Cost.
	Miles.		$ cts.		$ cts.
Cabins	....	2	66 50	....	66 50
Fences	....	1	45 50	....	45 50
Trail supplies	....	....	922 07	....	922 07
Miscellaneous	....	....	80 11	....	80 11
Total	....	3	1,114 18	....	1,114 18

TABLE 20.

CYPRESS HILLS FOREST.

Project.	Miles.	Number.	Cost.	Ranger Labour.	Total Cost.
			$ cts.		$ cts.
Cabin	....	1	16 00	....	16 00
Total	....	1	16 00	....	16 00

TOTAL OF UNCOMPLETED IMPROVEMENT PROJECTS.

TABLE 21.

Project.	Length.	Number.	Cost.	Ranger Labour.	Total Cost.
	Miles.		$ cts.	$ cts.	$ cts.
Trail maintenance	320		397 02	738 13	1,135 15
Cabins		10	1,130 60	145 04	1,275 64
Telephone supplies	62		962 02		962 02
Fences		3	45 50	54 37	99 87
Trail supplies			922 07		922 07
Fire-line maintenance	3		29 00		29 00
Boundary marking	17		50 50		50 50
Fire-fighting tools			177 18		177 18
Repairs to cache		1	14 20		14 20
Miscellaneous			195 09		195 09
Total			4,923 18	937 54	4,860 72

The trails constructed were of two types, standard and secondary. Standard trails are intended to form the main avenues of communication within the forest reserve, and are built with the idea of making such communication as rapid and easy as possible. You will understand that practically the entire Rocky Mountains are accessible to horses by means of open land along the streams, old Indian trails or through the timber where it is not obstructed by excessive wind-falls. The rate of progress, however, along such routes of travel is exceedingly slow. The packers and other travellers in the mountains ordinarily consider from twelve to fifteen miles as a day's trip for pack and saddle horses, and their custom is to travel about six hours, making two miles or two and a half miles an hour and then stop for the day. Feed is reasonably abundant, so that it is not generally necessary to give much consideration to this point. Such slow progress, however, is not well adapted to the exigencies of fire protection. To reach a fire with a reasonable degree of promptness we should be able to travel for two or three days at the rate of twenty-five to thirty miles per day. In order to do this the main routes of travel must consist of trails that are a very great improvement over any of those existing in the mountains prior to the creation of the forest reserve. The standard trails are built according to the following specifications: All brush must be cut from six to ten feet wide, the widest cutting being in reproduction about ten to twenty feet high and the narrowest being in heavy green timber; all overhead branches must be cleared out so that they will not interfere with men on horseback; the trails are to be as straight and direct as possible between the two termini, but must be built on dry ground, avoiding muskegs, except where this is impossible. The grade is not to exceed 10 per cent, except for short pitches which will not be more than 100 feet long, not over fifteen per cent in gradient and should not occur more often than once in two miles; the trail is to have a graded tread throughout its length, this tread varying in width from sixteen inches on comparatively level land, to two feet on the steeper hillsides. On hillsides the tread is to be on the lower side of the cleared line, and all soil and rock from the grading is to be thrown in the form of a ridge on the outside edge. The tread at switch-back turns must be made on a grade of not to exceed three per cent and must be three times the width of the ordinary tread for a distance of eight feet on each side of the point of the turn. In descending steep slopes one or two long grades are to be preferred to a number of short switch-backs. Wherever necessary in crossing muskegs and swamps corduroy should be placed, laid at right angles to the trail. The material forming the corduroy must be at least six feet long and three inches in diameter at the small end. Wherever possible, larger material should be used up to

eight feet long and six inches in diameter at the small end. All corduroy should be laid on not less than three sills and should have side logs laid on top of the corduroy which should not be less than six inches in diameter at the small end. Where possible some of the corduroy sticks should be spiked to the sills. All small streams up to 25-foot spans should be crossed by bridges or culverts. Bridges are to consist of stringers running lengthwise of the trail with not less than eight-foot poles laid across the stringers. These poles must be not less than four inches in diameter at the small end and should be spiked to the stringers and held down by guard-rails laid along the side of the bridge, which guard-rails shall be not less than six inches in diameter at the small end. In crossing streams by fords care must be taken to secure a good solid gravel bottom, free from mud and quicksand. The cost of trails built according to these specifications will run from $25 to $60 per mile, but they will easily double or triple the distance that can be made through the mountains in a day.

Secondary trails will form a means of communication within the primary system of standard trails. Long journeys of more than a day would not ordinarily be necessary on secondary trails and the same standard of construction will not be needed. The total mileage of secondary trails will be many times greater than of standard trails, but the cost will ordinarily be very much less. The construction of secondary trails will in many cases consist of clearing out, straightening and widening the existing Indian and prospectors' trails, eliminating the worst grades and corduroying some of the worst muskegs. Secondary trails will not in any case be cut more than six feet wide, will not have a graded tread except on the steeper hillsides, where a tread not to exceed eighteen inches in width shall be made. The grades of such trails may run up to 20 per cent for long slopes and 35 per cent for short pitches. Corduroy on secondary trails may be made by laying long poles lengthwise of the trail to form a tread about four feet wide. Bridges, however, must be constructed similar to those provided for standard trails, but only the worst of the small streams and sloughs need be bridged. The same care in selecting fords should be followed with these trails as with standard trails, and overhead branches should be cut out just as thoroughly. The cost of such trails will run from $5 to $15 per mile, but the great majority will cost under $10 per mile.

The telephone construction work will follow the same specifications and methods of construction as have been developed by the United States Forest Service. These methods are the result of about eight years' experience during which some thousands of miles of line have beeen built, and I do not feel that we are in a position to make any improvements or alterations.

For ranger cabins we are adopting three general styles of building. For use of permanent district rangers who are employed the year round and reside practically throughout the year at the same stations, we intend to erect houses of five to seven rooms, two storeys in height, built, in most cases, of lumber. These will be erected only at the most important stations where there is important timber sale, grazing or permit business which requires the presence of a year-long ranger. Such districts at the present time are confined to the forest reserve south of the Red Deer river. These buildings will ordinarily cost about $1,000, and along with them it will be necessary to construct a barn with a capacity of six to eight horses which will cost about $350 to $500. A pasture at each station will also have to be fenced and a water supply developed either by digging a well or improving a spring or other natural source of supply. Two such stations were constructed during the year and plans are being made for two or three more during the next fiscal year.

In the northern portion of the reserve, from the Red Deer river to the Athabaska, the main headquarters will consist of log buildings from 16 feet by 22 feet to 18 feet by 24 feet, inside dimensions. In most cases these buildings will be floored and roofed with lumber and will be divided into two or three rooms by board partitions. A small barn in connection with each one will ordinarily be provided. These cabins will form

the main district headquarters, from which the work of protection and administration will be directed during the working season, but in all that portion of the reserve north of the Red Deer river the working season corresponds only to the fire season, and during the rest of the season the force is very greatly reduced and the winter force is concentrated by the supervisor on such lines of improvement and development work as can be carried on during the winter. The third class of buildings are those known as caches. These are small log buildings from 10 feet by 12 feet to 14 feet by 16 feet inside dimensions. They are being erected throughout the Forest Reserve at all of the main trail-intersections and points where it is necessary to station temporary forest rangers during the fire season. The object of these cabins is to enable forest officers to range their districts without the necessity of packing with them a large amount of equipment in the form of tent, stove, food supplies, &c. This will greatly increase the mobility and, therefore, the effectiveness of the fire-ranging force. These cabins will ordinarily be constructed at from $50 to $125.

It will be readily apparent that, in order to provide adequate facilities for communication within the Forest Reserve, to insure a reasonable degree of fire protection, it will be necessary to construct several thousand miles of trail, some hundred or more cabins and a considerable mileage of telephone lines. We have not yet secured sufficient information in regard to the entire reserve to give a reliable estimate of the probable cost of the permanent improvements. Enough information has been secured, however, to indicate that this will be a considerable sum and the question naturally arises whether or not the risk justifies the expense. This would be a question of very considerable importance, were it not evident that by proper organization a very large portion of the permanent improvements can be constructed incidental to the fire protection. It has already been pointed out that to secure adequate fire protection a small, but efficient and well trained, permanent staff must be maintained, this staff forming the nucleus for a larger temporary force hired only for the dangerous season. It should further be understood that on the Rocky Mountain Forest Reserve the season of fire danger is divided into two seasons of extreme drought, between which there is a period when the abundance of green vegetation and occasional showers or snows makes the danger less acute. This has already been commented upon in connection with Table VIII. During the intermediate period it is scarcely possible to figure on reducing the force to any material extent for the reason that more or less danger of fire is always present and for the further reason that it is not practicable to secure men for short periods in the early summer and late fall and distribute them over such a wide area of mountain country. For these reasons the temporary summer force will have to be employed both during the two extremely dry periods and throughout the intermediate period covering the months of July and August. It is evident that much of the time of this temporary force throughout the summer, as well as a fair proportion of the time of the permanent force during the entire year, will not be required either for fire-patrol or for administrative work. The organization must be so perfected that all of the time not needed for fire-patrol or administration work can be utilized for permanent improvements or other permanent development work. The amount of such time available will, of course, depend upon the character of the season, but on the average it should be fairly large and through the proper utilization of this time a very large amount of the permanent improvements should be constructed.

In order to put the improvement work upon a clear-cut and well organized basis and to provide every facility for taking advantage of opportunities to utilize spare time on permanent improvements, thereby increasing the efficiency of the force, it has been found desirable to require the supervisors to make up a carefully drawn plan of all the improvements necessary on the reserves. These plans are still in the course of preparation but will be completed within the year. Supervisors are now required to submit detailed estimates of the improvements which they wish to have constructed during the fiscal year and to secure authorization for such work by projects. A detailed record of the cost of each project is maintained and monthly reports of the

expenditure and progress made are submitted to the inspector. At the end of the year an annual improvement report showing the work accomplished during the fiscal year is required of each supervisor, and in this report the projects are described in great detail and the itemized cost of all are shown. This improvement plan will form an important part of the working plans for the entire reserve and is largely supplemental to the fire plan which has previously been described, since the success of the fire plan depends very largely upon the construction of the improvements provided for in the improvement plan.

SILVICULTURE.

It has previously been pointed out in your reports that the great bulk of the merchantable timber in the Rocky Mountains Forest Reserve has already passed out of the ownership of the government into the hands of owners of timber licenses. It has also been pointed out that in spite of the vast area of the Rocky Mountains Forest Reserve the actual amount of standing merchantable timber within the reserve is comparatively small, although the amount of young growth and reproduction is enormous. The question naturally arises as to what policy the Forestry Branch should follow in disposing of the merchantable timber which still remains in the hands of the government. It must be realized at once that this reserve will not for many years constitute a source of lumber supply for the adjacent agricultural community. Lumber, except in limited quantities from the existing timber berths and in very small quantities for local consumption, cannot be secured from the Rocky Mountains Forest Reserve until the immature timber which occupies from 75 per cent to 90 per cent of the forest reserve at the present time grows to saw-log size. Aside from an insignificant amount of saw-log material which may be produced on the reserves at the present time, the great bulk of the reserve products will consist of such material as house-logs, fence-poles and fence-rails, railway ties, mining timbers and cordwood. It is apparent that the reserve will serve three rather distinct purposes. It will constitute an almost inexhaustible source of supply of such timbers as fencing material, house-logs, roof-poles and a limited supply of saw-logs valuable for consumption by small local mills of a portable character.

The second class of products will be ties and mining timbers. This is a product of great importance throughout the Rocky Mountains Forest Reserve because of the great development of coal mines that is taking place in all parts of the reserve. The mining of coal, as is well known, requires the use of enormous quantities of timber and the cost of production and, naturally, the cost of the final product is to a considerable extent dependent upon the price at which the necessary mine timbers can be secured. It will undoubtedly be better business policy to retain the timber within reach of coal mines for use in mining, thereby influencing the price of coal to the ultimate consumer, than to encourage the cutting of this timber for direct consumption and thereby force the importation of mine timbers from a distance.

The third purpose which the reserve will serve is in the production of cordwood. So enormous are the quantities of dry cordwood which are annually going to waste on the Rocky Mountains Forest Reserve that there seems no reason whatever for placing any restrictions upon the utilization of this product or its distribution over as wide a territory as possible.

The disposal of timber on the forest reserves is still being handled under the existing regulations through the Dominion Land offices.

The following tables show the timber disposed of on the forest reserves in the Alberta inspection district during the fiscal year ending March 31, 1913:—

TABLE 22.

TIMBER CUT UNDER SETTLERS' PERMITS.

Forest.	No. of Permits.	Lumber.	Logs.	Cordwood	Fence-Posts.	Fence-Rails.	Roof-Poles.	Receipts.
		F.B.M.	Lin. Ft.	Cords.				$ cts.
Crowsnest.......	176	15,250	142,568	1,651	26,390	25,135	17,045	318 13
Cooking Lake...	5	14,250	200	25	420	3,800	700	1 25
Bow River......	17	....	11,000	123	2,214	5,300	1,040	22 45
Cypress Hills...	317	....	603,655	3,747	89,315	109,940	92,612	103 05
Total.........	515	29,500	757,423	5,546	118,339	144,175	111,397	444 88

TABLE 23.

TIMBER CUT ON PERMIT BERTHS.

Forest.	No. of Permits.	Lumber.	Logs.	Ties.	Cordwood	Fence-Posts.	Fence-Rails.	Mine Timbers.	Receipts.
		F.B.M.	Lin. Ft.		Cords.			Lin. Ft.	$ cts.
Crowsnest.,..	11	3,197,577	40,250	6,686	25	400	400	74,689	3,499 68
Bow River...	3	753,607	....	....	....	....	....	....	530 33
Brazeau......	3	....	....	60,000	....	....	....	21	1,436 50
Cypress Hills.	1	103,660	......	....	....	....	....	....	29 80
Total.	18	4,054,844	40,250	66,686	25	400	400	74,710	5,496 31

TABLE 24.

TIMBER CUT ON LICENSE BERTHS.

Forest.	Number of Berths.	Area.	Lumber.	Mine Timber.	Lath.	Cordwood	Posts.	Receipts.
		Sq. Miles.	F.B.M.	Lin. Ft.		Cords.	Lin. Ft.	$ cts.
Crowsnest..	12	309,31	3,676,415	565	....	59	6,517	5,144 33
Bow River......	16	465,66	18,167,683	....	1,904,100	....	21,670	13,292 00
Total.........	28	774,97	21,744,098	565	1,904,100	59	28,187	18,436 00

NOTE.—None of the berths on the Clearwater, Brazeau or Athabaska Forests are operating.

TABLE 25.

TIMBER SEIZURES.

Forest.	No.	Saw Logs.	Bld. Logs	Cordwood	Fence-Posts.	Roof-Poles.	Dues.
		No.	Lin. Ft.	Cords.			$ cts.
Crowsnest	5			2		406	17 25
Bow River	2	37,427	10,018				6,572 00
Cypress Hills	8			1	402	46	28 33
Total	15	37,427	10,018	3	402	452	6,617 58

HAY PERMITS.

The land offices are also handling the issuing of permits to cut hay, and the volume of this business is indicated in the following table.

TABLE 26.

HAY PERMITS.

Forest.	No.	Tons Cut.	Receipts.
			$ cts.
Cooking Lake	9	277	27 20
Cypress Hills	54	1,837	187 20
Bow River	6	395	11 50
Crowsnest	5	2,556	238 65

TABLE 27.

TOTAL OF TIMBER AND HAY RECEIPTS.

Forest.	Amount.
	$ cts.
Crowsnest	8,979 39
Bow River	20,428 28
Brazeau	1,436 50
Cooking Lake	28 45
Cypress Hills	348 38
Total	31,221 00

NOTE—There was a small revenue from permits for stores which were issued by head office. No record of this is available nor is the record of the revenue derived from mineral resources at hand.

It is almost superfluous to draw attention to the anomalous character of the situation which now exists in the Department in connection with the disposal of timber, particularly in connection with forest reserves. It is specifically provided in section 11 of the Reserves Act that 'Nothing in this Act shall affect or prejudice any right or interest for cutting timber or for any other purpose in respect of any lands within a reserve.' The Act then goes on to provide that when land so licensed is denuded of merchantable standing timber that such land may thereupon be withdrawn from the lease or license. The result of the interpretation which has been placed upon this section is that all of the timber licenses within the forest reserves, which in this district include practically all of the merchantable timber within the reserve, are entirely beyond the control of the Forestry Branch and are administered by the Timber Branch in the Land Office. However, while being deprived of any control of the operations on the berths, the Forestry Branch is made responsible for the protection from fire, not only of the timber adjacent to the berth, but also of all standing timber on the berth itself. The Forestry Branch is also made responsible for keeping licensees from committing trespass by cutting outside of the limits of the berth and it is further given an interest in the land by the provision of the Act which makes possible the elimination of lands from the berth when denuded of merchantable standing timber. It will be readily apparent that this condition of divided authority contains some very clear-cut elements of weakness. Many operations carried on within the limits of timber berths have a very close relationship to the kind of fire protection which may be secured, not alone of that timber located within the berth, but also of all the timber in the immediate vicinity. It is true that the licenses under which these berths are operated provide that 'The licensees............shall dispose of the tops and branches and other debris of lumbering operations in such a way as to prevent as far as possible the danger of fire in accordance with directions of the proper officers of the Department of the Interior.' This would seem to be a fairly comprehensive provision, but the matter is not quite so simple as it appears upon the surface. The practical result of this provision is that no disposal of debris whatever is made upon the licensed berths, and there can be no doubt that these berths upon which logging operations are going on constitute an ever increasing menace to the fire protection of the timber in their vicinity. One radical obstacle to the only completely effective form of disposing of logging slash lies in a further provision of the licenses which provides that no timber less than ten inches in diameter at the stump shall be cut except that which is actually needed for road construction and other purposes of operation. It is the evident intention of this provision, which contains a further clause that the licensee 'shall not have the right to cut any trees that may be designated by the proper officer of the Department of the Interior as required to provide a supply of seed for the reproduction of the forest,' to provide for reproduction and the securing of a second cut or the maintainance of the crop of timber upon licensed land after the first utilization. The futility of trying to practise forestry by means of blanket regulations which are made to apply to all species, types and conditions of timber over an area which is practically continental in extent is only too clearly illustrated by the results obtained under this clause. However, this opens up a question of considerable magnitude and one which I do not feel properly comes within the limits of this report.

GRAZING.

Under existing Forest Reserve Regulations grazing of live stock within the Forest Reserve is prohibited. There seem to be no reasonable arguments in favour of this absolute prohibition, while there are several reasons why grazing within the forest reserves should be permitted, providing it is done under regulations that will make the grazing subordinate to the primary purpose of forest reserves, which is, naturally, the production of timber. There can be no question that the allowing of unrestricted

grazing within the forest reserves would not only be wholly antagonistic to the extension of the existing timber-bearing areas, but would very likely cause a diminution in the already established tree-growth. Furthermore, these results will take place even under a system of grazing which thoroughly conserved the forage itself and from a stockman's standpoint alone might be considered perfectly satisfactory.

The advantages of permitting grazing within the forest reserve are that, in the first place, we thereby provide for the utilization of a valuable natural resource in the form of grass and other forage plants which otherwise not only goes to waste but actually constitutes a serious fire danger and, in the second place, by having this grass eaten off we do not only reduce the fire danger but the stock in wandering over the reserve cut it up by trails which serve as fire lines, should a fire happen to get out. Furthermore, we secure the friendly interest of a large number of people because of the fact that fires in the reserve endanger the forage upon which their stock is dependent.

In considering grazing within the Rocky Mountains Forest Reserve the one point which must always be kept in mind is that grazing is purely incidental to the larger work of timber administration. It is incidental to this if only because of the fact that the grazing land within the reserve constitutes a very small proportion of the total area of the forest reserve. Grazing lands within the Rocky Mountains Forest Reserve are confined to two very limited classes of land. One of these consists of narrow strips of meadow land lying along the main stream-valleys and seldom exceeding half a mile in width. The other class of grazing land consists of high mountain slopes which for the most part, are in grass because they have been denuded by fire. There is practically no grazing land in the Rocky Mountains Forest Reserve which is devoid of tree-growth because it is above the tree line, since the limit of tree-growth in most instances in these mountains is determined more by the lack of soil than by climatic factors. It is doubtful if more than one per cent of the Rocky Mountains Forest Reserve has any value for grazing purposes and a very large portion of this, lying in the Clearwater Forest Reserve, has an extremely small carrying capacity.

Another factor in connection with the grazing possibilities within the Rocky Mountains Forest Reserve is the shortness of the grazing season. There is only one considerable body of grazing land within the reserve which affords range for stock the year round, and, unfortunately, this is, perhaps, the poorest body of grazing land in the reserve. The great bulk of the remainder is available for grazing only during a three-to-five-months summer season and is divided up into many small bodies of grass lying in narrow strips along the numerous streams which flow out of the mountains into the adjacent foothills and prairies. It appears, therefore, that the grazing land within the Rocky Mountains Forest Reserve, while it constitutes in the aggregate a fair-sized body of land, yet is very widely scattered in small, irregularly shaped areas, interspersed through, and intimately associated with, timber-bearing lands, and that, furthermore, much of it lies at extremely high elevations and is subject to excessive snow-fall, which limits the period of its usefulness to a comparatively short summer season.

If it is admitted that the permitting of grazing within the forest reserves, under suitable regulations, would be beneficial to the reserves, in order to be in a position to draw up suitable regulations, we must keep in mind not only the primary object of the Forest Reserve administration, which is the production of timber, but we must also, after safeguarding this interest, decide upon the fundamental policy in the administration of the incidental resources, which in this case is the forage crop.

Three primary objects suggest themselves in connection with this work. The first is the conservation of the existing range within the reserve. Without doubt it is the duty of the Forestry Branch to handle this resource in a way that will maintain it unimpaired for continuous use in the future. In the second place the

Forestry Branch should have in mind the improvement of the existing range by careful, scientific study of range conditions and methods of handling stock on the range. It has been shown on the national forests of the United States, where there were over 12,000,000 head of range stock grazed within the forests, that a great deal can be accomplished in the improvement of existing range areas when the matter is given the proper expert study. This, however, is a subject which almost of necessity must be dealt with by the Government rather than by private individuals. The third purpose which our grazing administration should serve should be the encouragement of mixed farming in the region adjacent to the reserve. The necessity of bringing about a change in the methods of agriculture in many parts of the western provinces has been before the public for a long time and is very generally understood and appreciated, and any provision whereby small farmers could obtain summer range for stock during the period when their land was under crop would, in my opinion, assist very materially in bringing about the change from straight grain production to mixed farming, which is generally recognized to be so desirable.

There are two systems of administering grazing lands, both of which are used extensively in the United States and in Canada. One of these is the acreage-lease system, which is used by the Dominion Government in the administration of its grazing lands outside the Forest Reserve, and by the State of Texas, by the Northern Pacific and Southern Pacific Railways and the United States Indian Department. The other system is the permit system, which is used exclusively in the national forests of the United States, where more than 12,000,000 head of stock graze annually under permit, and also by certain lumber companies who are owners of timber land in the States on which grazing of stock is carried on.

A brief consideration of the question from the standpoint of the forester will show that there are several important objections to the application of the acreage lease system for the handling of grazing within a Forest Reserve, especially under the conditions which exist throughout the Rocky Mountains. The principal objection arises from the fact that any lease, no matter how carefully worded, must of necessity grant in the lease certain property rights in the land which the Government is bound to respect. Unfortunately, these rights would in many instances be antagonistic to certain lines of forest administration. For instance, under a lease system it would be impossible to close an area to grazing if it was found, subsequent to the issuance of the lease, that grazing was bringing about the destruction of an established-reproduction. It would also be impossible to consider the artificial establishment of forests upon land held under a grazing lease, either by seeding or planting, during the term of the lease. It would, furthermore, be impossible to secure reproduction on burns or cut-over land indicated within a lease during the term of this lease, because to secure such reproduction would of necessity involve the closing of the area to grazing stock.

Another very important objection along a different line is in the relation of grazing to Water Conservation. Next to production of timber perhaps the most important function of the Rock Mountains Forest Reserve is the conservation of water for irrigation, power and municipal water supply. It is well known that the grazing of stock, particularly sheep, unless very carefully regulated, can have an extremely detrimental effect on the forest as a conservator of water and regulator of run-off. This is particularly true where a watershed is used for a municipal water-supply. For instance, any system of grazing administration which could not be readily adjusted to the requirements of the city of Calgary, which draws its municipal water supply almost entirely from the Rocky Mountains Forest Reserve, would be almost unwise.

From the standpoint of the stockman, also, the permit system has certain advantages over the lease system. For instance, it not infrequently happens that forage is destroyed by fire, insects or other causes. Under the lease system the stock would

have to be removed from the reserve to find forage elsewhere. Under the permit system it frequently happens that allotments may be so readjusted that such removal is rendered unnecessary.

Viewing the subject from another angle, that of the small users of forest reserve range, who, it must be remembered, are very greatly in the majority, it is apparent that the permit system has some very decided advantages. For one thing, under a lease system, small holders would be almost entirely barred from the use of the range which, as stated before, is of necessity only available for a three or four months' period, for the reason that they would not be able to stand the expense of holding their stock upon the extremely small allotments that would fall to their share. This could only be remedied by requiring the fencing of the leases and thereby precluding all possibility of recognizing new applicants who might justly demand some consideration in the use of the range, and it would also very greatly interfere with the administration of the forest reserve by cutting it up with numerous interior fences in a very undesirable way.

The permit system entirely avoids all of these objections. Under this system annual permits are granted to graze a fixed number of stock upon an area whose boundaries are described in a rather general way according to natural features or the limits imposed by drift-fences. This system is extremely flexible and interposes no barrier to readjustments that are rendered necessary to accomplish the objects of forest management above specified. It is of course apparent that to administer a system of this sort there must be a classification of applicants for grazing privileges which will determine the consideration or preference which they will have in obtaining these privileges. Various methods of so classifying applicants have been suggested, but to my mind certain factors appear to have primary importance. In the first place, it will be generally agreed that preference should be given to persons who own improved ranch or farm property over persons who merely run stock as a speculative venture without having a fixed location in the country. Again, among owners of improved ranch and farm property it seems reasonable to give preference to resident owners as against non-resident. Moreover those residents who are in the near vicinity of the forest reserve would naturally have a somewhat greater claim upon the reserve range than those who live at a distance. Furthermore, there seems ample justification for giving preference to the small ranch and farm owner, the home-builder, who in many cases will be greatly handicapped, if not absolutely barred from properly establishing himself and making a living, unless he can secure summer range for the stock which he can carry through the rest of the season upon the products of his land holdings. Keeping these factors in mind, I do not think that any insurmountable difficulty will be encountered in administering regulations that will secure the accomplishment of these objects. Priority in the use of the range has by some been urged as the logical dominating factor in determining preference, but I do not think this is a factor of primary importance. For one thing, a very large part of the range has never been used at all, so that no priority has been established. For another thing, the use of the range which has thus been made has been wholly unauthorized and illegal, and the Government would not be justified in recognizing it as a primary factor in the determination of a preference. Where it is a question as between two owners who are equally qualified in all other respects, I should say that the prior user should secure the preference, but not under any other conditions.

There are, of course, numerous minor details in connection with a system of grazing regulations, based upon such principals as I have outlined, which must be taken into consideration. A number of these were suggested in your report for the year 1912. Much information of value can be secured from the experience of other Governments or large land-owners with a system of this sort. Many other details will have to be settled as cases arise in the field. The most essential factor to be considered is the absolute necessity of having certain fundamental principles care-

fully determined which will guide us in adjusting our regulations and rendering our decisions to meet the varied conditions which arise in the field.

In preparation for the inauguration of a system of grazing regulations within the Rocky Mountains Forest Reserve a very detailed examination of the reserve boundary is being made in order to determine the location and extent of grazing lands adjacent to the boundary, both inside and outside the forest reserve. This is a matter of particular importance for the reason that the forest reserve boundary in a general way shows the limit between the true grazing lands of the foothills country and the absolute forest land of the mountains. It may occasionally happen that small areas are included within the forest reserve which are chiefly valuable for grazing. I have had a number of specific cases cited to me in which it was urged that such lands along the boundary of the reserve were valuable only for grazing purposes and that these lands could be handled much more satisfactorily under a lease system than under a permit system. I have almost invariably found on field examination that the most desirable way of handling these cases was not by modifying the general system, as proposed, but by eliminating these lands from the forest reserve because of unsuitability. The total area, however, of such lands is wholly insignificant, and can very readily be determined by the present boundary examination.

A grazing problem with which the Forestry Branch will probably be called upon to deal is that of furnishing summer range for sheep. At the present time there is no portion of the Rocky Mountains Forest Reserve which is being grazed by sheep, the stock on the reserve being exclusively cattle and horses. I have already pointed out, however, that there are large areas of grazing land within the reserve which have never been utilized for pasture for any kind of stock. Certain of these areas are particularly adapted for sheep range. Aside from the objection to sheep which is made by most cattle-owners, the only objection I have ever heard urged to the running of sheep on the Rocky Mountains Forest Reserve was the presence of wolves and coyotes in dangerously large numbers. Undoubtedly some arrangement would have to be made for the extermination of these animals before sheep grazing in the forest reserve would be very attractive. This could be accomplished either by offering a bounty, or by employing hunters for the special purpose of hunting down wolves and coyotes. In opening the reserve to sheep it would, of course, be necessary to consider the prior claims of owners of cattle and horses who are established along the forest reserve boundary and who in many places will have first preference for the forest reserve range. I do not believe that the Department would be justified in considering the admitting of sheep to any portion of the forest reserve which is now occupied by cattle or which has adjacent to it sufficient cattle to stock the reserve. There are, however, certain valleys which would make excellent sheep range which do not have any cattle running on them at the present time, and which do not have in the vicinity a sufficient number of stock to require all of the forest reserve range, should it be opened to grazing. In such places where access can be had to the range without conflict arising between owners of cattle and sheep, I believe that it it the duty of the Department to make provision for summer grazing of sheep. Three areas of range land which satisfy these conditions are the valley of the Livingston river between the first and second ranges of mountains, the valley of the Kanaskis river, and an area of high mountain-range between the Sheep river and Jumpingpound lying at the foot of the first range of mountains well behind the range, which is now occupied by cattle and horses adjacent to the eastern boundary of the reserve.

TRESPASS.

The subject of timber trespass is something to which I have given particular attention during the past season, because of the fact that such a large expenditure is being made on the forest reserves for the purpose of preventing trespass without

apparently accomplishing any material results. For instance, on the Cypress Hills Forest Reserve, which was created July 13, 1906, the Land Office's records show that last year a total of only $28.33 was collected as the result of eight seizures made of timber cut in trespass on this reserve, while our own records show that $1,089, which is 26·2 per cent of the entire expenditure on the Cypress Hills Forest Reserve was expended for the purpose of preventing trespass. It must be perfectly evident that there is something radically at fault when, on a forest reserve which has been under administration for seven years, it is still necessary to expend over 25 per cent of the total appropriation to prevent the stealing of timber. In striking contrast to this condition is the report of the District Forester of District No. 1 of the United States Forest Service, which adjoins the Alberta Inspection District on the south, covering the thirty forest reserves of that district and extending from Michigan to Washington, and from the International boundary to Utah and Wyoming. The total acreage of forest reserve in this district is in the neighbourhood of 33,000,000 acres, while the total acreage of the Cypress Hills Forest Reserve is only 99,840 acres, and yet in District No. 1 no expenditure was made specifically for the prevention of trespass during the fiscal year 1912, as against 26·2 per cent of the entire allotment to the Cypress Hills Foreste Reserve alone.

In the Alberta Inspection District the fundamental defect in our system of handling this matter lies in the fact that the penalty for stealing timber from Dominion lands is so light as to constitute no deterrent whatever. The only penalty which can be imposed, or, at least, which has ever been imposed, on persons cutting timber in trespass is to seize the timber and release it upon the payment of double dues. The dues, however, upon this timber are not fixed at the market value of the timber, but in many cases are as low as one-quarter of the actual commercial value. A very great number of people are perfectly ready to take the risk of cutting timber upon Dominion lands and forest reserves under these circumstances, knowing that even if detected the fine imposed will still allow them to secure the timber at less than one-half its actual market value. The result is that, instead of decreasing, timber trespass appears to be actually on the increase. The only way in which this matter can be successfully dealt with is to make the penalty for the unlawful cutting of timber from forest reserves so severe that persons will think twice before committing such a trespass. In connection with this a vigorous effort must be made to detect and convict in every case where trespass has occurred. This is the system which was followed in the adjacent reserves in district No. 1 of the United States Service and the result is that timber trespass has practically ceased to exist. Unless the matter is handled in this way our annual expenditure for the purpose of detecting unlawful cutting will continue to increase without the slightest improvement in the condition which gives rise to the necessity for this expenditure.

A particularly flagrant trespass which occurred last year was that of the Great West Lumber Company within the Bow River Forest Reserve. This trespass, which occurred in connection with the operations of the Great West Lumber Company on Berth No. 1,100, involved $6,572 worth of timber. It appears that this company operated for two entire seasons wholly outside the limits of its berth. The difficulty, to my mind, is due to the division of authority as regards timber trespass between the Dominion Lands Office and the Forestry Branch. The timber berths inside the forest reserves are specifically exempted from the operation of the Forest Reserves Act, and this has been interpreted to place the control of the operations on these berths in the hands of the Timber Branch of the Land Office. While the Crown Timber Agents have entire control of all operations within the berths, the Forestry Branch is responsible for their protection from fire and it has also lately been ruled that the control of the Land Office does not extend to the requiring of timber berth operators to confine their operations within the limits of the berth. In other words, while the Crown Timber Agent has entire jurisdiction within the lines of the berth, the Forestry Branch is charged with seeing that the operator does not cut outside of these

lines. The practical difficulty arises from the fact that many of the berths are so old that the lines are overgrown and almost completely obliterated. Since the Crown Timber Agents control only the operations within the berths, it therefore devolves upon the Forestry Branch to delineate in some way the limits of these timber berths. This will, of necessity, involve a very large expenditure for surveys unless, as I feel can be reasonably required, the owners of timber berths be required to reblaze and restore such boundary lines as have become obliterated or obscured so that they may readily be located on the ground.

ACCOUNTS.

Next to the improvement of the personnel, one of the lines of the forest administration which called for the most radical reorganization was the system of Accounts. Previous to the fiscal year just ended it does not appear that any serious effort was made to ascertain the distribution of expenditures upon the forest reserves nor to keep a cost record of the forest reserve activities according to modern methods of accounting. The permanent staff was paid directly from Ottawa and the officer in charge of each reserve was given an advance of funds from which he settled all charges for temporary emergency labour and for the purchase of supplies. No books were kept which would enable the supervisory officers to determine currently the condition of the appropriation for any one reserve, nor was there any uniform system of keeping books in connection with the cash disbursements of the supervisory officers from the advance made for this purpose. The government was protected only by the requirement that receipts in duplicate for all expenditures above $1 should be submitted, and no other check upon expenditures other than this simple requirement existed. The principal defect in the system, however, arose from the fact that there was practically no record obtained as to the cost of any of the forest reserve activities, so that it was wholly impossible to determine what degree of efficiency was being secured or to fix in any accurate way the responsibility for inefficient service.

One of the first steps taken by my office was an entire reorganization of the accounting system which is as yet not entirely completed. It was not thought desirable to undertake to establish an extremely elaborate accounting system at once for the reason that most of our officers were unacquainted with modern systems of accounting, and had up until the present year not been required to handle work of this sort at all. For this reason it was thought best to employ, at first, an extremely simple method which could later be elaborated to any degree which might be felt to be desirable. The first step was to establish a uniform system of book-keeping throughout the district. By this system a continuous record is kept available at all times for the supervisor's information showing the total expenditure from his appropriation and the balance available. Supplementary to this he has a set of acccounts which show the distribution of his expenditure among seven main sub-heads and each sub-head is suitably classified according to its character. For instance, each supervisor is required to keep a separate record of the cost of each improvement project, such as a building, trail, road, etc., and the expenditure for such a project is further classified so that he knows, for each such project, the cost of temporary labour, ranger labour, material, tools, subsistence, freight and miscellaneous charges. The one major defect in the system as in effect during the past year is the fact that no record is kept showing the cost of forest activities in ranger labour aside from the labour which is expended upon permanent improvements. In view of the fact that a total of $47,557.59, or considerably more than 50 per cent of the expenditure in the district, went for salaries during the past year, it is evident that we should have detailed information as to the cost of the various lines of work which were covered by this large expenditure. This omission in the cost-keeping system was deliberate because it was known that any procedure which would secure reliable figures on this subject must of necessity be rather complex and it was desired to introduce no greater

complexity into the system at the start than could be avoided. For the next fiscal year, however, a system of accounting which will give us this information has been devised and will be put into effect.

A very radical change in the method of paying accounts was made in the district. Instead of distributing advances to be deposited to the personal accounts of the forest supervisors and disbursed by them on personal cheque, the disbursements were all concentrated in the office of the district inspector and the supervisors were required to submit their certificates of expenditure to this central disbursing office for payment. The locating of this office at Calgary greatly facilitates the handling of a system of this sort and has worked out to the entire satisfaction of all concerned. It occasionally happens that emergency labour accounts, such as for fire or improvement work, have to be settled in cash at the supervisor's headquarters. In these cases, which have thus far been limited in number, advances of the necessary cash have been made to the supervisor by the disbursing officer at Calgary, and payments have been made with all necessary promptness.

While the organization of the disbursing end of our fiscal system has progressed satisfactorily the subject of receipts has still to be dealt with. The revenue from the forest reserves in this district is as yet small, but it is increasing, and there is no doubt that in a short time it will assume fair proportions. At the present time all the revenue from the forest reserves is received and accounted for by the Dominion Land Agents in whose districts the reserves are located. There is a very decided objection to this method of handling receipts for the reason that under the method of procedure followed in the department the officer who receives the payment must also be the officer who issues the permit or grants the privilege for which the payment is made. While the land offices are equipped to receive and account for payments for privileges granted upon the forest reserves, which is merely a matter of routine, they are not equipped to handle the issuing of the permits for these privileges. The reason for this lies in fundamental differences in the objects aimed at by the administration of the Dominion lands and timber in the Land Office and in the Forestry Branch. So radically different are these objects that a system of procedure and regulations which are admirably adapted to accomplish the purpose of the Land Office administration of timber is absolutely antagonistic to the accomplishment of the Forestry Branch administration of timber. The Forestry Branch is charged not only with the disposal of timber at a reasonable rate, but it is further charged with the disposal of timber under such form of regulations as will accomplish the object for which the reserves were created, namely, the perpetuating of the timber-supply. When timber stands upon agricultural land which it is desired to clear and open for settlement, as is the case with much of the timber outside the reserves handled by the land offices in this district, it is sufficient to provide a procedure which will secure to the government a reasonable price for this timber, insure public competition, and provide that it shall be utilized with a reasonable degree of intensity. When, on the other hand, it is desired, as on the forest reserve, not alone to dispose of the mature standing timber but to do so in such a manner that the land from which this timber is cut will be left in a condition to continue indefinitely to produce merchantable timber, it is obvious that a radically different method of procedure must be adopted.

The same condition exists in regard to the subject of grazing. It is readily possible to handle grazing on the forest reserves through the Land Office in accordance with the system of procedure which has been developed in the land office and with which Land Office officials are familiar. To do so, however, would be radically opposed to the object for which the forest reserves were created, since grazing in the forest reserves is wholly incidental and must be, of necessity, subordinated to the primary purpose of the reserve, which is the production of timber. A system of grazing administration which gives satisfactory results upon land that is valuable and in many cases available only for grazing will not necessarily, or even probably, give

satisfactory results upon land which is intimately associated with timber-bearing areas, as is the case within the forest reserve. Practically the same condition exists in connection with all other privileges which may be secured upon reserved and unreserved Dominion lands, except perhaps as regards mining operations. In practically every line of work the regulations which are adapted to accomplishing the objects aimed at in the Dominion Land offices are either poorly adapted, or in many cases are antagonistic, to the regulations which are required in order to accomplish the objects of the administration of land in forest reserves. For this reason it is obvious that where, as in most land offices, the forest reserve business is simply incidental to their larger work of administering the unreserved public lands, the reserves work must, almost of necessity, be very imperfectly understood and inadequately handled. This leads to continuous misunderstandings between the two branches and to delays for which neither is wholly responsible but which create an extremely bad impression among forest-users. It would seem to be very much simpler to provide a receiving office, to handle exclusively the forest reserve receipts than to endeavour to educate the very large number of Dominion Land Offices which have dealings with forest reserve matters to the objects of the forest reserve administration and the details of field procedure. In fact, as this administration becomes more developed, this difficulty will become very much intensified, and it would appear that it would be more satisfactory to all parties concerned to relieve the land offices of the necessity of receiving and accounting for forest reserve revenue and issuing permits for forest reserve privileges, as has already been done in the case of the Dominion parks.

This work could very readily be handled for the entire district in the office of the district inspector without any very material increase in staff or expenditure and would thereby relieve, in this district alone, five separate land agencies of this class of work, and four separate agencies in the Manitoba district. By adopting this procedure throughout the branch the work which is now distributed between ten separate land agencies could be concentrated in three district inspectors' offices, much to the advantage both of the Forestry Branch and the Dominion Land Offices.

SURVEYS.

One of the most important and fundamental requirements in the organization of a forest reserve is an accurate survey and map. The Rocky Mountains Forest Reserve, since it contains no land of agricultural value, has not been subdivided into sections according to the system of the Dominion Lands Survey. The only sectionized portions of the reserve are in the vicinity of coal mining claims and these surveys, although scattered very widely throughout the reserve, cover a comparatively small total area. Three lines of survey work appeared to be urgently necessary. One of these was the establishment of the eastern reserve boundary. A preliminary line was run at the time the reserve was created, but this line was not marked up on the ground with sufficient prominence to serve the requirements of forest reserve administration. It needs no discussion to show the absolute necessity of having such an arbitrary line prominently marked on the ground in order to guard against timber, grazing and other forms of trespass and to give the public proper notice of the limits of the forest reserve. This boundary marking is being carried on and will be completed by the end of the next year. Throughout those portions of the reserve which border upon a settled community, the line will be marked up in such a way that no reasonable excuse for trespass can be offered.

A second line of survey work is considered to be necessary especially in the large reserves north of the Red Deer river. The maps available in much of this country are hopelessly inaccurate, and before a start at proper organization can be made it will be necessary to correct the more obvious errors. For this purpose a system of

rather extensive topographic mapping will be employed, by which the main stream-valleys will be located with considerable accuracy and the minor features of the country sketched in as time permits. A complete topographic survey based upon a system of triangulation will not be attempted, but reliance for the primary control will be placed upon the base-lines and other lines of the rectangular surveys which have been projected into the mountains. In connection with this work the co-operation of the Topographical Surveys Branch has been secured, and this branch is undertaking to make a photo-topographic map of the entire Crowsnest Forest Reserve during the next year.

The third line of surveys which has been found to be necessary is the accurate location of the sites for ranger stations and cabins, which are ordinarily referred to as administrative sites. It was found that failure to have these sites located by an accurate survey was resulting in the construction of numerous buildings on land which did not belong to the government, or which was encumbered by various forms of leases that interfered with its use for administrative purposes. In some cases, even, cabins were constructed outside the borders of the forest reserve because of inaccurate determination of the location of the building sites. To guard against such errors, supervisors have been required to survey with a reasonable degree of accuracy all sites where it is proposed to construct cabins or other permanent improvements and to submit these surveys together with evidence that the land is owned by the government without encumbrance before receiving authority to proceed with the construction work. The proper location of administrative sites is a very essential part both of the fire plan and the improvement plan, and too much emphasis can scarcely be placed upon getting these sites carefully located and properly co-ordinated with the entire plan for improvements and the plan for fire protection.

FISH AND GAME.

The relation of fish and game protection to forest administration is a subject upon which a great deal of misunderstanding exists. Under the existing laws the fish within the forest reserves are entirely under the control of the Dominion Government, while the game is entirely under the control of the Provincial Governments. In this district the fish situation has been very carefully studied by the Fish Commission, and regulations were drawn up and put in force under date of April 1, 1912. The forest reserves were specifically exempted from the operation of these regulations, but after giving the matter some attention I feel that the situation within the reserve can best be handled by extending the regulations existing outside the reserves to apply to reserved land, with the important modification that all fishing of a commercial nature be prohibited. I do not think that there is any necessity for providing for a specific set of regulations or licenses within the forest reserves, but believe that every purpose of fish protection can be served by allowing fishing within the reserves under the license issued in accordance with the Dominion Fisheries Regulations for the province of Alberta.

Supplementary to this, however, the Forestry Branch should give special attention to the condition of the fish within the forest reserve and should provide closed seasons and special restrictions upon specific streams from time to time as the conditions warrant. It should be readily possible to enforce fishery regulations with the existing force of rangers and patrolmen within the reserves, since of necessity fishing is confined to a comparatively small and closely defined area.

The subject of game protection is radically different from that of fish protection. Hunting differs very materially from fishing in that the operation is not confined to any well defined locality and thereby the chances of detecting illegal operations are very greatly reduced. Suggestions have been made from various sources advocating the creation of the entire Forest Reserve into a game preserve. Any such action to my mind, would be highly undesirable and would lead to very strong and justifi-

able objections from the local population. It must be recognized that the Rocky Mountains Forest Reserve constitutes the only available big-game hunting ground of any importance in the prairie provinces, and that it affords an opportunity for hunting of certain big-game animals which are not found anywhere else east of the province of British Columbia. A very large and growing packing and guiding industry has grown up in the mountains, which is to a considerable extent dependent upon the possibility of securing big-game animals. During the past season I gathered statistics which indicate that the value of the big-game hunting in the Rocky Mountains Forest Reserve to the province of Alberta in the matter of licenses and revenue derived from hunting parties last year amounted to not less than $25,000. It must be further recognized that this industry is as yet in its infancy and that a very material increase can be looked for in a few years. The creation of the Forest Reserve into a game preserve would absolutely ruin this business without serving any good purpose that cannot be readily accomplished by other means. Moreover, the practical administrative difficulties which would be introduced by such an action are, I believe, very poorly understood by the persons who advocate such measures. To accomplish adequate protection within such a game preserve it would be necessary to increase very greatly the force of rangers and the expenditure for forest administration. I have already explained how it is possible, by taking advantage of weather conditions, to reduce very greatly the cost of placing the reserves in a first-class condition for administration and protection and to maintain them in such a condition. This, however, arises from the fact that the fire season is itself limited to a comparatively small portion of the year and that within the fire season the times of extreme danger are further reduced by the local weather changes. In game protection there is no such distinction between periods of great danger and periods of immunity. The game laws may be violated any time of year that a man can get into the mountains, regardless of weather conditions or any other factors, and a game guardian must be continuously on the lookout to prevent such a violation. In this he differs radically from the fire guardian, who can adjust his watchfulness entirely to the conditions of the season and weather. In the popular mind the duties of fire and game warden are generally considered to be very much the same thing. As an actual matter of fact there are certain radical differences which are of considerable importance in forest administration. These differences, however, are not so great that it is not feasible to combine the two duties in the one man, but, unfortunately, the distinction between a forest ranger and a game and fire guardian is likewise not appreciated by most people and this is a far more important one. I have already described the duties of a forest ranger in some detail and from this description it will readily be understood that the combination of forest ranger, game guardian and fire guardian in one and the same person is a practical impossibility. Should the Forestry Branch undertake to administer the Rocky Mountains Forest Reserve as a game preserve, it would be absolutely necessary to provide a complete staff of game wardens distinct from the staff of forest rangers. Furthermore, I am convinced that even such a system would not insure adequate protection, and that the only way in which to secure adequate protection of the Rocky Mountains Forest Reserve as a game preserve would be to place the use of the reserve under the extremly close restrictions which are applied to the Dominion parks. Such restrictions would of necessity prevent the grazing of stock, the cutting of timber and the establishment of camps or summer resorts except under very strict and costly supervision, would interfere in a most undesirable manner with the prospecting of the reserve for minerals, with the development of coal mines, oil prospects, etc., and would involve the establishment of a system of espionage upon travellers and tourists within the reserve that, in my opinion, would be very generally and very justifiably resented. I believe that the object of game protection, about the value of which there can be no question, can be adequately served without disturbing any legitimate interests by the establishment of a series of game refuges

distributed throughout the Forest Reserve, which shall be limited in area and so located as to interfere in the least possible manner with the full enjoyment and utilization of the Forest Reserve for the purposes for which it was created. Close study of the entire reserve should be made in order to fix upon areas which are natural breeding-grounds for game, which can be described by natural boundaries so as to facilitate administration and which do not contain timber, grazing or mineral resources that are valuable public assets. These areas should then be established as game preserves by Forest Reserve regulations, which can be done under the provisions of the existing Forest Reserves Act without requiring any amendment or other parliamentary action. These game refuges would then act as breeding-grounds, from which the surplus would overflow into the adjacent Forest Reserve areas and afford ample opportunities for hunting, both to the local population and to non-resident big-game hunters, who contribute very much to the prosperity of the province both directly and indirectly. One such game refuge lying in the extreme southern portion of the Crowsnest Forest Reserve along the international boundary has already been tentatively suggested. I have also made examinations in many other parts of the Forest Reserve from the International boundary to the Athabaska river with this object in view and will complete this work during the next season.

SUPPLIES AND EQUIPMENT.

The subject of supplies and equipment, although relatively small in comparison with such subjects as organization, improvements, fires, etc., has not infrequently caused considerable loss of time and money. Working as we do under a requirement that practically all office supplies must be secured on requisition from Ottawa, it has not infrequently happened that delays in receipt of necessary supplies have caused delays in field-work, the cost of which many times exceeded the value of the supplies themselves. Similar losses of time and money can be traced to the unsuitability of some of the equipment furnished. The system of procedure now in use is to submit semi-annual requisitions to the supply clerk at Ottawa for routine supplies and to secure emergency supplies from a stock maintained by the district inspector at Calgary. This is working satisfactorily, but the troubles at present experienced are due to the entire lack of standardization in the supplies furnished. This gives rise to great difficulty and expense in making up a proper requisition, to innumerable mistakes and misunderstandings, to the furnishing of much unsuitable equipment, to many unnecessary delays and to a loss of time and money wholly out of proportion to the magnitude of the question involved. The whole matter could be easily and quickly placed upon a systematic and economical basis by adopting a standard list of supplies and equipment, including in this list those articles which experience has shown to be necessary for the office and field work of the Branch, and having all supplies conform to detailed specifications, which, determined after a conference between the head office and the inspectors' field officers, should then be confined to the use of these standard supplies, and not only would the process of making up requisitions be greatly simplified, but a vast amount of correspondence which is now necessary to adjust misunderstandings would be wholly eliminated. Periodic revision of this standard list and the specifications for the equipment by a committee of field-officers working in co-operation with the clerk of supplies would insure the adjustment of the list to any changes in conditions that might occur.

EDUCATION AND PUBLICITY.

Bringing before the public the work being carried on by the Forestry Branch has not been lost sight of in the district, although there has not been any great opportunity to follow up such work aggressively. The fact that most of the work done by the branch lies in very remote portions of the mountains, often as far as two

or three weeks by pack train from the nearest railway point, has a tendency to keep the work of the Branch more or less out of the public eye, which does not occur with those departments whose officers are in constant touch with the public. During the past year the inspector has attended a number of conventions, at most of which he delivered addresses on the work being done in the Alberta Inspection District. The most important of these were the annual convention of the Canadian Forestry Association at Victoria in September, the annual meeting of the Western Forestry and Conservation Association at Seattle in December, a meeting of the forest supervisors and district officers of District No. 1 of the United States Forest Service at Boulder, Montana, in March, and a meeting of the Forestry Club at the University of Toronto during January.

A number of requests for lectures on forestry subjects and the work of the Branch have been received, practically all of which had to be declined because of lack of time and lack of facilities for illustrating such addresses which in most cases was felt to be necessary. It is believed that facilities for giving illustrated lectures at High schools and normal schools, colleges, clubs and other organizations of a similar character would be extremely useful and would be very much appreciated in the district. In order to provide such facilities, several lectures are being prepared, and lantern slides secured, together with a projecting lantern and other necessary apparatus.

The great extent of the forest reserves made it desirable that some method be devised to keep the forest officers throughout the reserves informed as to the progress of development work. To accomplish this object a quarterly publication, or newsletter, has been established known as the 'Rocky Mountain Review.' This paper is edited and printed in the office of the district inspector and contains a statement of the progress of the work on each of the reserves for the quarter, together with other items of interest to the officers of the Branch. It is also distributed to numerous forestry and lumber journals and to institutions which desire to keep informed of the progress of forestry work in the district.

A work which is thought to be of considerable importance, particularly to the employees of the Branch, is the establishment of a forestry library somewhere in the western portion of the Dominion. The inspector's head-quarters at Calgary would seem to be best fitted as a site for this library, because of the fact that such a large proportion of the employees in the outside service of the Branch are located in the Alberta district. There are, unfortunately, no facilities whatever for securing books on this subject in Western Canada, since there is no forest school or other institution provided with such a library, and the public libraries naturally do not stock more than a very small number of such publications. The Forestry Branch Library at Ottawa, while very complete, is too far away to be of much use to field-officers. For these reasons it is felt that a forestry library in Calgary would not only be of immense value to the officers of the Branch, but might be so organized that, with the co-operation of the Carnegie Library in Calgary or the Calgary University, it could be made available under suitable regulations and restrictions for use by the public.

Much interest has been shown by the local newspapers in the work of the Branch, especially in the Rocky Mountains, and every effort has been made to supply these papers with timely news of interest and to prevent the publication of exaggerated accounts of forest fires which frequently find their way into the newspapers unless facilities are provided for furnishing reliable and accurate information.

APPENDIX No. 3.

REPORT OF DISTRICT INSPECTOR OF FOREST RESERVES FOR MANITOBA.

FORESTRY BRANCH,
WINNIPEG, MANITOBA, March 31, 1913.

R. H. CAMPBELL, Esq.,
Director of Forestry,

SIR,—I have the honour to submit the following report on the several forest reserves in Manitoba and Saskatchewan, for that portion of the year ending the 31st instant, during which I have been the inspector, namely, since June 1 last.

RESERVES.

There are nine forest reserves in my district, namely, the Riding Mountain, Duck Mountain, Porcupine Mountain, Turtle Mountain, Spruce Woods in Manitoba, with the Moose Mountain, Beaver Hills, Pines and Nisbett in Saskatchewan.

STAFF.

On the above reserves 34 officers were employed as per Table No. 1.

WORK.

The work in which these officers were engaged was providing for the protection and management of the reserves by erecting houses for supervisors and forest rangers, cabins, stables, caches, telephone lines, cutting fire-lines, boundaries and trails, ploughing fire-guards, cutting out and constructing telephone lines, cruising for timber, locating tracts where settlers could obtain supplies of timber, patrolling for and fighting fire, watching timber-cutting operations, seeing that persons cutting timber left the debris in piles for burning, burning old slashes, taking requisitions and settlers for timber and hay permits, checking the cut and returns of cuts, collecting dues, taking up expired permits, making seizures of illegally cut timber or hay, and collecting dues where required.

BUILDINGS.

Some thirty buildings have been erected, one house commenced and two previously in use improved. Other buildings are provided for, to be taken in hand when the weather permits. The class and distribution of these buildings on the several forest reserves is shown in the attached Table No. 2.

It is the intention to have all rangers, and some of the supervisors reside permanently on the reserves, as soon as accommodation can be provided, and it is hoped that this will be in the near future, as it has been found that their residence away from the work causes considerable loss of time.

BOUNDARIES AND FIRE-LINES.

The boundary lines of the reserves are being cut out and marked as fast as circumstances will permit, and a very considerable proportion of some of the older

reserves has already been finished. So far, no general practice has been established nor is it thought possible to do so, owing to the different conditions prevailing. Various plans have been tried, such as (1) cutting wide lines through the bush country, piling the debris in the centre and burning it; (2) cutting lines of similar width, piling the debris in the centre and ploughing the full width of the cleared space; (3) ploughing two to four furrows on either side of the wide line and burning between (with the intention of later on ploughing the full width of the strip). The relative advantages of these different plans have yet to be established.

Owing to the broken nature of the land in many districts ploughing cannot be done, and the best method of protecting such areas has not been ascertained, but it is hoped that a burning machine, now being developed, may prove successful.

A scrub-cutting machine of recent invention, which has proved its usefulness and practicability, is to be tried this season on the Turtle Mountain Forest Reserve, where conditions are thought to be most favourable, and if it proves a success this machine can be moved to other localities or additional machines can be secured.

The trails through many of the forest reserves are expected to prove of great assistance in reducing fire risks, and these will be further improved as circumstances will permit.

FIRES AND FIRE-FIGHTING.

Owing to the very favourable conditions of last summer, I am able to report that practically no fire damage was done. In the Duck Mountain Forest Reserve one fire covered some 145 acres, did estimated damage of $100 and cost $79.50 to extinguish; another in the Riding Mountain forest reserve, was more of a prairie than a bush fire, covered some 400 acres, but did not destroy any timber of value and cost $3 to check.

Such favourable conditions can hardly be looked for again during the coming season, and the matter of establishing and maintaining efficient fire-guards should be one of the chief objects of the officers of the Branch; the public should also be fully instructed to be most careful in lighting fires when clearing land, and compelled to watch such fires closely at all times.

Fire-fighting equipment has been furnished to the forest rangers, in the way of tools, and on the Duck Mountain Forest Reserve, twenty strongly built boxes have been distributed, some among the forest rangers, others with responsible settlers residing close to the range. Those boxes are well painted and fitted with locks, and each contain six round-mouthed shovels, three grub-hoes, two axes, three canvas water-buckets, and file for sharpening tools. The settlers with whom these have been placed have arranged to act as foremen in case of an outbreak of fire, to secure immediately such assistance as may be necessary and to notify the supervisor or nearest forest ranger, without delay. They are to receive slightly higher pay, while engaged, than the ordinary men.

Lookout towers on commanding hills are to be erected, some sites have already been selected and a portion of the required material placed. Where possible these will be connected by telephone with the rangers' houses and headquarters, and outside points, so that assistance may be secured without delay. The lower portion of these towers will be arranged as shelters for camping in, store rooms for tools and provisions as well as telephone booths.

ROADS AND TRAILS.

The roads and trails given in the table cover, as far as shown, are all existing, both new and old. These latter will be improved as speedily as possible, by widening, clearing, bridging, etc., and they, in conjunction with the new ones, will furnish easy access to the interior and enable fire-fighters to reach seats of danger, settlers to take out timber, and the reserve officers to traverse the reserves much more quickly

than is now possible, many long detours being at present necessary. Some of this work will entail considerable expense, especially is this the case with an old colonization road originally built by the provincial government in the Riding Mountain reserve, connecting the Dauphin and the Gilbert Plains country with the south at Elphinstone, on which there are several muskegs requiring bridges or substantial corduroy. This, however, has been in general use by the public while passable, and it is hoped that the provincial authorities may render some financial assistance, as also, perhaps, in the case of other roads similarly used.

The forest rangers will be called on to locate and plot on maps such trails as exist in their several districts.

One very important road is that which was commenced this winter, starting at the northwest corner of the Riding Mountain Reserve, running southeast to connect with one from near Norgate opened to Clear lake. It will have connections with the ranger stations, to two of which it is already connected, and some sixty-five miles of the main road and offshoots have been completed. The deep snow prevented further work this spring. All streams met were bridged, soft places conduroyed, and telephone poles distributed as far as the supply found adjacent would permit.

When completed this road will enable forest officers to traverse the reserve from one end to the other, touching at all ranger stations, and will obviate the long detours on roads outside of the reserve that are now necessary.

TIMBER-CUTTING OPERATIONS.

The establishment of forest reserves and enforcement of the regulations being of comparatively recent date, prior to which settlers could cut and slash with great freedom, considerable difficulty has been found in securing compliance with the regulations, but it is hoped that ere long the public will awaken to the fact that it is imperative for the welfare of the country as a whole that all possible precautions be taken to protect the rapidly diminishing supply of merchantable timber, and to secure a new stand, by guarding the growing trees, manufacturing in the most economical way, and replanting as rapidly as the appropriations and conditions will allow.

Three small new berths were disposed of in the Riding Mountain reserve and a renewal granted for one other in a certain burned district. These were granted to the successful tenderers after public competition had been invited, and carried the right to locate a saw-mill on the berths secured and dispose of the product on the open market; the stumpage dues offered were $2.10 and $2.25 per M feet, board measure. The successful tenderers made deposit of $100 each furnishing bonds of $200 by themselves and two securities, guaranteeing that they would operate in accordance with the regulations governing such berths. Further, each holder takes out a permit for such amount of lumber as he considers he can manufacture during the season paying twenty per cent of the dues down, and the balance from time to time as his returns of manufacture, made each three months, show how he is indebted.

PERMITS TO LOCATE MILLS TO OPERATE IN GREEN TIMBER.

Permits to locate mills in the reserves were granted to two individuals and a renewal of one from last year was issued. These provided that the operator might locate where directed by the supervisor of the reserve, and cut such timber as is mature and advisable to have taken out, the product to be disposed of only to settlers under permit. The mill may be located as soon as the application has been accepted by the Department, and cutting may be done to the extent of 100,000 feet board measure, in advance of the securing of settlers' permits, thus enabling the operator to do his work before the snow gets too deep, and have a supply on hand with which to fill such permits as may be presented to him. The right to so locate was secured by public competition, a deposit of $100 was made, and bonds of $200 by the owner and two

securities given for the carrying out of the conditions governing the contract. The chief consideration taken into account in accepting such tenders as were offered were the class and equipment of the mill, the prices at which the tenderer agreed to deliver lumber to the settler, and the general standing of the applicant as a mill and bush man. This plan is thought to be of great benefit to the settlers in saving delay and to the Department in the reduction of waste, and the logging being done by one person who has a vested interest, the forest officers find it less difficult to enforce the regulations.

The prices at which the several operators agreed to deliver timber to settlers at the mill are given in the attached table. These figures do not, however, include the Government dues.

REVENUE.

Attached is a table giving returns of timber taken from the several reserves during the fiscal year, with Revenue from same.

SUMMER RESORTS.

Two summer resorts are in existence, one at Max Lake in the Turtle Mountain Forest Reserve, where a number of houses have been erected, some for several years; new ones, moreover, will be put up this season. It is largely patronized by the residents of the towns in the vicinity, and persons from a distance are expected to build in the near future. Efforts have been made to induce someone to establish a refreshment booth and stable for the accommodation of campers, but so far without success. A site for a recreation ground will be selected and improved, but as yet no area sufficiently level has been found.

The resort at Fish Lake in the Moose Mountain reserve has attracted a number of people. A road has been built to it, and this will be further improved and it is expected that more lots will be taken up and houses built during the coming summer. This is an ideal spot, the bathing, boating and fishing being excellent.

Madge Lake in the Duck Mountains, within easy reach of Kamsask, is a favourite camping ground. So far no houses have been built, but a road has been made and this season more people are expected to take advantage of this charming spot.

Clear Lake, in the Riding Mountain, will, it is thought, be largely used by the inhabitants of the towns and villages to the south, as soon as a survey can be made of a portion of the shore to be set apart for lots, and it is the intention to improve the road leading to it, so that automobiles can travel on it.

I would suggest that every possible endeavour be made to open up any suitable locations for such resorts, as being a means of securing the interest of the public in the preservation of the forest reserves in general.

GRAZING.

In the tract on the Turtle Mountain (some 27,000 acres, fenced for this purpose), 94 head of stock only were taken in, the fees being $92.75. The stock is the property of eleven owners. The results were so good that it is expected that many more settlers will this year avail themselves of the privilege. This work will no doubt be extended to other reserves, where pasturage facilities exist, and requests have already been made by stock-owners for similar enclosures to be made on the Spruce Woods and Riding Mountain reserves.

Respectfully submitted,

F. K. HERCHMER,

District Inspector of Forest Reserves for Manitoba.

Schedule of Officers attached to Reserves.

Reserve.	Supervisors.	Forest Assistants.	Forest Rangers.	Assistant Rangers in Winter.	Herders.	Game Guardians.
Riding Mountain	1	1	7	2		
Duck Mountain		1	7			
Porcupine Mountain	1					
Moose Mountain	1		1			1
Turtle Mountain	1		1		1	
The Pines	1		2			
Nisbet						
Spruce Woods	1		1			1
Beaver Hills	1					
Total	7	2	19	2	1	2

Settler's Permits issued by Manitoba Agencies.

Reserve.	No. of Permits.	Lumber.	Logs.	Cordwood	Fence-posts.	Fence-rails.	Roof-poles.	Receipts.
		Ft. B. M.	Lin. Ft.	Cords.	No.	No.	No.	$ cts.
Dauphin Agency :—								
Riding Mtn	411	1,174,781	8,660	3,329	11,685	2,840	800	2,145 70
Duck Mtn	240	778,147	12,214	1,138	12,959	15,000	3,143	1,235 12
Porcupine								
Total	651	1,952,928	20,874	4,467	25,270	17,840	3,943	3,380 82
Brandon Agency :—								
Riding Mtn	1	10,000						30 25
Turtle Mtn	190	36,200	1,400	4,267				161 50
Spruce Woods	57		1,000	1,113				40 00
Moose Mtn								
Total	248	46,200	2,400	5,380				231 75
Summary	899	1,999,128	23,400	9,847	25,270	17,840	3,943	$3,612 57

Settlers' Permits issued by Saskatchewan Agencies.

Regina Agency :—								
Moose Mtn								
Estevan Agency :—								
Moose Mtn	16			156				21 25
Saskatoon Agency :—								
The Pines	2		200	4				2 50
Prince Albert Agcy :—								
The Pines	53	64,070	9,500	1,110	4,600	10,000	3,000	212 75
Yorkton Agency :—								
Beaver Hills	83			1,156				20 75
Duck Mtn	17	106,759						25 25
Summary	171	170,829	9,700	2,426	4,600	10,000	3,000	$282 50

Grazing Permits.

Reserve.	No.	Head.	Receipts.
Turtle Mtn	11	115	$92 75
Total	11	115	$92 75

Lease of Camping Lots.

Reserve.	No.	Lots.	Receipts.
Turtle Mtn	42	42	$122 75
Total	42	42	$122 75

Schedule of Trails—Old and New.

Reserve.	Length in miles.
Duck Mountain	90
Riding Mountain	150
Spruce Woods	30
Turtle Mountain	50
Moose Mountain	20
The Pines	50
Beaver Hills	12
Total	402

Schedule of Enclosures.

Reserve.	Area enclosed.
	Acres.
Duck Mountain	15
Riding Mountain	50
Spruce Woods	1
Turtle Mountain	27,000
Total	27,066

Schedule of Telephone Lines.

Reserve.	Miles in Reserve.	Miles out of Reserves.	Total Miles.	Instruments installed.
Duck Mountain	22½	1½	24	3
Riding Mountain	21	4	25	2
Spruce Woods	3	2½	5½	1
Turtle Mountain	2½	1½	4	1
Total	49	9½	58½	7

Schedule of prices charged by Millowners operating in Forest Reserves on Timber under Settlers' permits per M ft., board measure.

Location.	Spruce, Jack Pine Tamarack, Balsam Fir.	Poplar.
	$ c.	$ c.
Riding Monntain No. 1	14.00	12.00
" " No. 2	15.00	14.00
Duck Mountain	12.00	....

Sawing only.

Location.	Spruce, Jack Pine Tamarack, Balsam Fir.	Poplar.
	$ c.	$ c.
Riding Mountain No. 1	5.00	5.00
" " No. 2	6.00	5.00
Duck Mountain	....	....

Schedule of Nursery.

Reserve.	No. Beds.	In Good Order.	Estimated No. Trees per Bed.	Two Years in Bed.	Total Seedlings.	Trans-plants Set Out.	Species of Trees.
Spruce Woods	40	31	3,500	3,150	108,500	4.665	White Spruce, Jack Pine, Scotch Pine, Bull Pine, Lodgepole Pine, Douglas Fir, European Fir, Tamarack.

Schedule of Buildings.

Reserve.	Houses Complete.	Houses in course of Erection.	Cabins.	Stables.	Storehouses.	Telephone Booths.
Duck Mtn	2	1	2	3	2	....
Riding Mtn	3	....	2	3	1	1
Spruce Woods	1	....	2	2	....	....
Turtle Mtn	1	....	2	1	1	....
The Pines	1	....	....	1	....	....
Moose Mtn	1	....	....	1	....	....

Timber seized.

Reserve.	No. of Permits.	Lumber.	Logs.	Cordwood	Fence-posts.	Fence-rails.	Roofpoles.	Receipts.
	No.	Ft. B.M.	Lin. ft.	Cords.	No.	No.	No.	$ cts.
Riding Mtn	12	1,318,482	540	12	....	....	....	1,333 10
Duck Mtn	3	6,870	....	10	....	....	....	97 60
Spruce Woods	....	....	....	....	....	....	....	....
Turtle Mtn	....	....	....	....	....	....	....	....
Porcupine	....	....	....	....	....	....	....	....
Total	25	1,325,352	540	22	....	....	....	$1,430 70

Excess paid on Timber Permits.

Reserve.	No. of Permits.	Receipts.	—
Riding Mtn	20	$50 30	
Duck Mtn	26	42 55	
Total	46	92 85	

Hay Permits issued.

Reserve.	No. Permits.	Tons.	Receipts.
			$ cts.
Dauphin Agency—			
Riding Mtn	53	977	108 75
Duck Mtn	4	25	4 50
Porcupine	....	....	....
Total	57	1,002	113 25
Brandon Agency—			
Turtle Mtn	52	821	110 1
Spruce Woods	14	230	34 50
Total	66	1,060	144 60
Summary for Manitoba	123	2,062	257 85
Regina Agency—			
Moose Mtn	22	350	67 00
Estevan Agency—			
Moose Mtn	9	207	18 25
Saskatoon Agency—			
The Pines	....	....	....
Yorkton Agency—			
Beaver Hills	....	....	....
Duck Mtn	....	....	....
Prince Albert Agency	....	....	....
Summary	31	557	$85 25

Dead Timber Berths.

Reserve.	No.	Receipts.
		$ cts.
Riding Mtn	4	705 75
Total	4	$705 75

Green Timber Berths.

Duck Mtn	1	100 00
Riding Mtn	1	100 00
Total	2	$200 00

APPENDIX No. 4.

REPORT OF DISTRICT INSPECTOR OF FOREST RESERVES FOR BRITISH COLUMBIA.

Forestry Branch,
Kamloops, March 31, 1913.

R. H. Campbell, Esq.,
Director of Forestry,
Ottawa.

Sir,—I have the honour to submit herewith an annual report of the work done under my supervision in the Kamloops District of the Railway Belt of British Columbia during the year ending March 31st, 1913. The Kamloops District includes that part of the Railway Belt lying between the boundary line between Township Tiers 10 and 11, west of the 6th Meridian, easterly to the Alberta boundary.

The activities of the Forestry Branch in this district can be divided under three main heads, viz., forest reserves, fire ranging and Railway Commission co-operation, and will be dealt with separately.

FOREST RESERVES.

The Forest reserves in the Railway Belt comprise a total area of some 523,000 acres, consisting of isolated plateaux or table-lands of from 3,500 to 6,000 feet, with occasional peaks rising considerably higher in some localities. These plateaux are clothed almost entirely with lodgepole pine. Douglas fir and yellow pine occupy some of the lower slopes on the outer edges, and form the only tracts of really merchantable timber on these forest reserves.

These forest reserves all form the headwaters of numerous small streams and creeks which descend from them to the main drainage levels in all directions. Situated as they are in the 'Dry Belt' these waters are very valuable for irrigation purposes. Indeed, watershed protection rather than timber conservation was the main reason for establishing these reserves.

Personnel.—The administration staff during the summer season of 1912 consisted of five forest rangers, three of whom are permanent appointees. These rangers worked directly under the direction of the inspector's office at Kamloops. The appointment of a forest supervisor was made during the winter. To this officer will henceforth be delegated the actual administrative work on forest reserves.

From the above statements it will be seen that the average area under the charge of each forest ranger is about 104,500 acres. On this area he is supposed, not only to prevent fires, but also to handle the timber and grazing business, and locate and construct trails, lookouts and other improvements. Under an efficient administration the fire patrol should be merely a side-line in a ranger's duties. The size of these districts precludes this possibility under present conditions, but it is hoped by the employment of temporary guards and establishment of lookout patrols to reach this stage of development in the near future.

Improvements.—Owing to the inadequacy of the appropriations available no extensive improvement work was undertaken last year. The only improvements important enough to be put on a project basis were the opening up of some 22 miles of

Trail in the Long Lake Forest Reserve at a cost of about $275, and the beginning of the construction of a stable for the Ranger Station at Trout Lake in the same reserve.

The total amount spent on improvements on forest reserves amounts to some $522, or approximately one-tenth of a cent per acre.

In addition to this cash expenditure the rangers spent a proportion of their time in building corrals, opening trails and similar work. Ranger labour on improvements amounted to $630, or approximately eleven-hundredths of a cent per acre.

Timber.—The demand for forest reserve timber in this district was practically nil last year, only two applications for settler's permits being received. This condition of affairs is due to two main factors, first, that there is a surplus of timber in this country, and, secondly, that these reserves being as above stated, namely, watershed-protection reserves, are situated in remote and fairly inaccessible spots, so that it is much easier for settlers to obtain timber from vacant Dominion lands outside of the forest reserves and nearer the settlements.

As settlement gets farther back sone timber will doubtless be required. Another source of demand will come from irrigation projects and summer resorts. The extensions proposed to the reserves also, being along the borders, approach now nearly to the settlements, and, containing as they do, from their lower elevation, timber of rather superior quality, will doubtless give rise in time to a quite active demand for timber.

Grazing.—The grazing business on the forest reserves already established in the railway belt is destined to become of much greater importance than the timber. The great increase in the world markets and consequent permanent high price of beef is a great stimulus to the cattle industry in this country.

The rapid settlement of the district and consequent depletion of leased grazing land of 50 per cent or over of the best areas and nearly all the watering places under homestead has necessitated the cattlemen depending more and more on forest reserve land for grazing. At the present time the use of leased land is practically confined to winter feed and spring calving, the forest reserve being used throughout the summer.

It will be seen, therefore, that the forest reserves are of paramount value to the cattle business. A computation of the acreage available for grazing outside the reserves shows that total holdings of leased and freehold do not amount to more than 40 per cent of the pasturage necessary to support the stock already owned. The forest reserves supply the other 60 per cent and can supply in addition, without overstocking, range for over twice the number of stock now owned in the country adjacent, provided that proper regulations were enforced.

Up to the present time there has been absolutely no administration of grazing in the forest reserves, and the cattle have ranged free throughout them since their establishment. The result is that the more accessible ranges have been much overgrazed, are being trampled out, and are in danger of permanent deterioration, while at the same time tens of thousands of acres of first-class grazing land are absolutely untouched.

The time has come for a rational administration of this resource. The new regulations recently drawn up provide the vehicle necessary and it is hoped that they will be put into force soon.

Table 1 shows the range area available in the grazing reserves, the number of stock using the range and the approximate range-capacity of each reserve:

TABLE 1.

DETAILS OF GRAZING ON BRITISH COLUMBIA RESERVES.

Forest Reserve.	Range Area.	Altitude.	Present Use.	Range Capacity.
	Acres.	Feet above sea-level.	Head of stock.	Head of stock.
Long Lake	75,000	3,500 to 4,500	1,500	5,000
Tranquille and Extensions	80,000	3,500 to 5,500	4,000	10,000
Hat Creek and Extensions	150,000	4,000 to 6,000	6,000	10,000
Niskonlith	50,000	3,000 to 5,000	2,000	5,000
Totals	355,000	...	13,500	30,000

Under the schedule proposed in the new regulations a net income of from $6,000 to $7,000 would accrue to the Department without imposing any hardship on the owners.

Boundaries.—The boundaries of existing forest reserves in the Railway Belt were delineated more or less arbitrarily, being agreed upon in the office rather than examined in the field. This was sufficient at the time of their creation, inasmuch as the sole idea was watershed protection. Only the headwaters country being important, it was sufficient to take a good safe boundary.

The rapid settlement of the country and increasing scarcity of timber led many people into homesteading lands for their timber. This soon made it necessary that examinations be made of the country lying adjacent to the forest reserves for the purpose of delineating properly the boundary of the absolute forest land, in order that it might be reserved for forest purposes rather than homesteaded for the timber growing on it.

The spread of information regarding the value of irrigation led to requests being made to the Department that other watersheds be included in forest reserves.

As early as 1908 examinations were made of the present forest reserves and new boundaries were suggested. This work was done by A. O. Wheeler, then of the Topographical Surveys Branch of the Department of the Interior. In 1909 surveys under the direction of J. R. Dickson, a forest engineer in the employ of the Forestry Branch, were made of other watersheds. He recommended that reserves be established in the Mount Ida and Fly Hills countries adjacent to Salmon Arm, and in the country lying east of the Thompson river between Ashcroft and the Nicola river over to the west boundary of the Long Lake Forest Reserve. No action, however, was taken on any of these reports until April, 1911, when the lands included were withdrawn from disposition by the Lands Office.

During the interval many entries had been granted by the Lands Office for lands within these proposed additions. This necessitated further corrections which were made jointly by the Superintendent of British Columbia lands, the Dominion Lands Agent at Kamloops and the District Inspector of Forest Reserves for British Columbia. The revised schedule was authorized in January, 1913. This schedule also included proposed reserves delineated during the season of 1912 by a forest survey in charge of H. S. Irwin and his successor, Bruce Robertson. This survey was the first placed in the field susequent to the organization of the British Columbia Inspection District.

It is the intention of the Forestry Branch to define the boundaries of all tracts of non-agricultural lands within the Railway Belt for the purpose of having them created into forest reserves. Lands within the 'Dry Belt' are being examined first, as the necessity for watershed protection is of the greatest importance. The additions proposed by this survey will, if passed, add some 540,120 acres to the forest reserve area in British Columbia.

A winter-reconnaissance party was put in the field on the Long Lake Reserve last December in charge of Forest Assistant K. G. Wallensteen. The object of this survey was to find out whether a fairly intensive reconnaissance could be carried out in winter as economically as in summer. If the experiment proved successful, it was thought a solution would be found for utilizing the time of permanent employees in the winter when the ordinary reserve work slackens off considerably owing to the depth of snow and general impassibility of the country. The experiment was not altogether a success from the point of economy, owing to the lack of experience in handling the problem of transportation of supplies and outfit. During the winter, however, methods were developed for solving this problem, so that it is expected that next winter a party can be operated with comparatively little extra cost over summer work. These methods include the packing in of the supplies and caching at convenient points in the district to be surveyed before the snow comes in the fall. The actual work of surveying is done on skis and snowshoes, depending on the character of the country. Where the former can be used they are much more efficient than the latter. The fact that the men are urgently needed in other work during the summer, and are not available for this work justifies their use in winter reconnaissance even at an increased cost of 10 to 25 per cent.

Interesting data were obtained by this survey in connection with silvical types in the forest. The lodge-pole pine, which is at present practically in complete possession, is only a temporary fire-type. It will be replaced under natural conditions by Douglas fir on the lower levels and Englemann spruce on the higher. Both of these species are of much greater commercial importance than the lodge-pole, so that the future of the reserve from an economic point of view is very bright.

In accordance with the policy of the Department to encourage public use of forest reserves a summer-resort town-site was recently surveyed at Trout Lake, a famous fishing resort in the Long Lake Forest Reserve. This resort, being at an altitude of 4,100 feet, has a magnificent summer climate, moderate days being succeeded by cool nights, in delightful contrast to the oppressive heat of the lower levels. Lots of two kinds are available to the public, viz., building lots, leased for a term of years and camping lots leased for the season, both at a nominal rental. Many applications for leases have been received, so that the success of this project is assured.

An interesting fact showing how the public appreciate this locality may be cited in the request from certain ladies of Kamloops to be allowed to construct a house to accommodate poor mothers with children during the hot weather when the infant mortality in town is very serious. This request received favourable consideration. and the building is well under way at the time of writing. Instances of this sort will go far to educate the public into the correct idea of the reservation of these areas of the public domain, viz., that they are for the use and enjoyment of the citizens of this country for all time.

FIRE-RANGING.

The Kamloops division of the Railway Belt was divided in 1912 into two fire-ranging districts, viz.:—

1. *Revelstoke District,* including that part of the belt lying east of Three Valley.
2. *Salmon Arm District,* including that part of the belt between Three Valley and North Bend.

Revelstoke District.—This district includes the western slopes of the Rockies, the whole of the Selkirks and the eastern slopes of the gold range within the railway belt boundaries, consequently the country is of a very mountainous and inaccessible nature.

The climate varies from a region of fairly heavy precipitation in the Columbia valley at Revelstoke to a fairly dry climate around Golden. Unfortunately, the rainy seasons occur so as to give comparatively dry periods in the spring and fall, times when the fire hazard is naturally greatest owing to the accumulation of vegetable matter. These conditions, while they may be described as average, are by no means of invariable occurrence. Extreme irregularity and uncertainty of precipitation is a noticeable meteorological feature of the country.

The timber of the country varies with the climate. On the Revelstoke side the heavy western cedar-hemlock type is found in the river-flat and lower benches, with Englemann spruce, Douglas fir, Alpine fir, Mountain balsam, and Western larch, in addition, on the mountains. On the Golden side the flats and benches bear principally spruce, lodge-pole pine and Douglas fir and, the mountain slopes have Alpine fir (Mountain balsam) in addition.

The fire hazard throughout these regions is abnormally high; indeed it might well be described as the highest in Canada. This is due to the climatic conditions mentioned above and to the nature of the forest itself. The latter factor may be subdivided into two, viz.: (1) natural conditions, and (2) artificial conditions. Natural conditions include the debris piled on the forest floor through windfall, natural decay, etc., which, especially in the cedar-hemlock type is very great. The interior of hollow cedar logs is very retentive of fire, which has been known to smoulder all winter under the snow and break out again on the coming of the dry weather in the spring. Another noticeable condition increasing the fire hazard, especially in the Golden district, is the presence of mosses and lichens of various kinds hanging from the lower dead limbs of the timber. These, being very inflammable, aid a ground fire to become a crown fire in a very short time.

Artificial conditions include the slash left after logging and clearing operations. This factor is by far the most important of any affecting the fire hazard in this part of British Columbia. Being artificial, it is, unlike the natural conditions mentioned above, capable of alleviation. The solution of this problem is the great question before the fire-protective resources of British Columbia at the present time. It is expected that during 1913 experiments will be instituted to secure data on this subject, which can be presented to the lumbermen as proof that it is to their own interests in the cause of true economy to burn their slash after each logging operation. Over 90 per cent of the disastrous fires which have done such incalculable damage to the timber of this country have owed their origin to a fire starting in slash. Every lumberman knows that it is inevitable that every slash will burn sooner or later. He is, in most cases, simply gambling on getting through with the locality before the catastrophe happens.

Sections (*e*) and (*f*) of the license under which timber berths are granted by the Department read as follows:—

> (*e*) That the licensee shall take from every tree he cuts down all the timber fit for use and manufacture the same into sawn lumber or some such saleable product and shall dispose of the tops and branches and other debris of lumbering operations in such a way as to prevent, as far as possible, the danger of fire in accordance with the directions of the proper officer of the Department of the Interior.
>
> (*f*) That the licensee shall prevent all unnecessary destruction of growing timber on the part of his men and exercise strict and constant supervision to prevent the origin or spread of fires.

These sections contain ample provisions to enable the Department to compel the lumbermen to adopt logging methods which would adequately safeguard the

future of the forest. Up to the present, however, no consistent effort has been put forth to enforce these regulations. Things have now gone so far, and some of the berths have changed hands so often, that it is probable the present owners might be presumed to have a right in equity to cut timber as they liked. It would appear a good investment, however, from an economical point of view, on the part of the Department, to remit a part of the dues or the royalty on the logs, when the logging is done in a careful and conservative way with some consideration for the succeeding, as well as the present, crop.

Comprising, as it does, a succession of mountain ranges, the Revelstoke district is for the most part of a very inaccessible nature. This makes the work of fire patrol and fire fighting particularly arduous. A fire ranger may discover a fire from some lookout point and have to travel a couple of days through trackless forest before even reaching the spot. If he decided or finds that assistance is necessary he may have to journey two or three days to the nearest settlement for men and supplies. In order to help to alleviate the situation, caches of tools have been put in throughout the region, and arrangements have been made with the railway company and with lumber camps, where found, for men available on call for fire fighting. Improvement work on a comprehensive scale is being planned to open up this country for fire-protective purposes. Such improvements include the construction of trails, tool caches, lookout stations and telephone lines. It is expected that a start will be made on this work during 1913.

The Revelstoke district is divided into twelve ranger districts. These men cover some 265,000,000 acres, or approximately 221,000 acres per man. They are supervised by a chief ranger, who is supposed to spend his time travelling from district to district and in being at every large fire to superintend operations and pay off the men. Nine of the fire rangers were newly appointed last year and in nearly every instance gave very efficient service. Considerable credit is due to the chief ranger, also a new appointee, for the able way in which he handled a very trying and difficult fire situation.

Last year a new Forest Act was passed by the Provincial Legislature which prescribed a close season for burning, during which permits have to be obtained for setting out fire. Under an agreement entered into by the Director of Forestry and the provincial Minister of Lands and Forests, the Dominion fire rangers took over the issuing of these permits within the limits of the railway belt. This co-operation led to much increased efficiency in the control of the settler's fire problem, and resulted in a great saving in trouble and expense to both parties.

On the conclusion of the fire season last fall a ranger's meeting was held at Revelstoke, at which the experiences of the different men were related and methods of patrol and fire fighting were discussed. The rangers were unanimous in asserting the importance of the question of slash disposal, and a large proportion of the time was spent on this subject.

The following resolutions passed are of interest:—

1. Whereas the question of slash disposal is the most important from a fire-preventive standpoint of any in this province,

Resolved, that in the opinion of this Conference, steps should be taken by the Dominion and Provincial governments to institute experiments to determine the safest, most efficient and most economical method of disposing of such slash. Carried.

2. Whereas it is not consistent or just that private corporations and individuals should be compelled to take certain steps in regard to the clearing of the rights of way and logged-over areas while the government roads are left in a dangerous condition through carelessness in leaving brush and debris undisposed of, and whereas numerous fires have already occurred and been fought by members of this conference, resulting from the leaving of such debris,

RESOLVED, that in the opinion of this Conference, steps should be taken immediately by the provincial Department of Public Works towards having debris and brush along the rights of way of provincial roads, both those now completed and those in course of construction, disposed of in a safe and efficient manner. Carried.

3. WHEREAS there can be no adequate fire protection in this part of the country until a comprehensive system of trails, lookouts, tool caches and telephone lines is constructed,

RESOLVED, that in the opinion of this Conference, the Dominion and Provincial governments should push forward the work of concentrating such improvements as fast as possible. Carried.

This ranger meeting was the first held in the interior of British Columbia. It resulted in the clearing up of many misunderstandings among the men and led to a considerable increase of interest and the rise of enthusiasm for the work on their part.

The fire season of 1912 in the Revelstoke district was characterized by two very distinct meteorological periods, a very dry spring, followed by a very wet summer. Practically no precipitation occurred from April till about June 13, when the rains started and lasted throughout the summer. During the dry season many bad fires broke out, some of which did a great deal of damage, both to property and to standing timber.

The most disastrous of these occurred in timber berths 15 and 16 near Golden, where operations were being carried on by the Columbia River Lumber Co. The origin of this fire is doubtful, but it was probably started either intentionally by one of the discharged employees, of whom a number were released the day or so before, or by a spark from a logging locomotive. This fire started on June 8, and, fanned by a strong wind, got out of control and burned up and down the Columbia river for five days, extending a distance of eight or ten miles. The company lost a set of camp buildings with supplies and a large quantity of logs. A very large area of valuable merchantable timber was fire-killed. A conservative estimate of the amount would be 100,000,000 feet, most of which, however, will be saved by immediate cutting. Fighting this fire cost the Department some $4,550.

Another bad fire occurred about two miles east of Donald on May 12. This fire started through the carelessness of sectionmen burning brush on the right of way. Carried broadcast through second-growth lodgepole by strong dry winds, this fire burned some ten square miles of country, mostly on the slopes of Donald mountain. It was fought in a desultory fashion by the Canadian Pacific railway for a while, and then left to burn itself out. The Dominion ranger, being occupied with other fires threatening heavy timber, was not able to spare much time for this one. This fire cost the Department some $120.

Another fire, presumably started by tramps, along the Beaver river at Sixmile creek burned over a large area of the mountain side and did extensive damage to young growth. This fire cost $800. All three of these fires were burning at the same time. They were finally extinguished by the heavy rains in the latter part of June.

During the rainy season an unusual number of severe electric storms crossed the country, starting innumerable lightning fires, most of which, however, were extinguished almost immediately by the rains. Many such fires, however, survived the storm and had to be fought. The most serious of these occurred up the Beaverfoot river from Leanchoil in the Yoho park. This fire was fought for over a month and cost some $1,800 to put out.

Altogether 23 fires occurred during the season which required special measures to extinguish. Of these 17 occurred before June 15. The total cost of fighting these fires was $10,950.53.

The causes were as follows:—

1. Unknown	8
2. Lightning	4
3. Settlers	4
4. Locomotive sparks	3
5. Clearing right of way	2
6. Camp-fires	2
Total	23

Excepting by the Golden fire, not much damage was done to standing timber. Owing to the large areas burned no definite data are available as to acreage concerned.

Salmon Arm District.—This district includes the western slopes of the Gold range, the Shuswap Lake country, the interior plateau and the eastern slopes of the Cascade range as far as North Bend. The country as a whole is much less mountainous and rugged. Mountain ranges are replaced by plateaux with comparatively wide valleys or reaches of agricultural land between. Settlements are to be found in all these places with good roads between, so that the district as a whole is very accessible.

The climate varies from the heavy precipitation characteristic of the Columbia valley at Revelstoke through successive dry stages until it is almost arid at Ashcroft and Spences Bridge. Between Lytton and North Bend precipitation increases again as the influence of the coast conditions become prominent. The presence of large bodies of water, such as Shuswap lake, give more regularity to precipitation in that region. Prolonged droughts in spring and fall are of rare occurrence, but there is a tendency to hot dry spells in midsummer.

The timber varies from the cedar, hemlock and white spruce of the Gold ranges to Douglas fir around Shuswap lake, with spruce and Alpine fir (balsam) on the higher plateaux. Farther west in the 'Dry Belt,' is yellow pine on the plateau. Douglas fir, hemlock and white pine begin to appear again around North Bend. The timber in the Gold range and around Shuswap lake is very good and is mostly taken up in timber berths. Farther west it becomes sparser and smaller, until in the heart of the 'Dry Belt' practically the only use it serves is for watershed protection.

The timber plateaux in the dry belt being mostly incorporated into forest reserves, the principal activities of the fire-ranging staff in this district are concentrated in the eastern part. The fire hazard here and also in the drier belt in the West is greatest in midsummer, and not in spring and fall. It is, however, at this time often very severe. Shuswap lake is peculiarly susceptible to electric storms, with the result that lightning fires are of common occurrence. The lake is, however, very efficiently patrolled, by a government launch so that these fires are kept under control. As in the Revelstoke district, the slash problem is of prime importance from a fire-protection standpoint. The slash here results principally from settlers clearing land, provincial roads, railway right of way, etc. Improvements have been planned in this district also, designed to facilitate more efficient protection; some of these will be undertaken during 1913.

The Salmon Arm district is divided into thirteen ranger districts. The total area of the districts being approximately 5,865,000 acres, an average of 451,000 acres per man is thus indicated. A chief ranger with headquarters at Salmon Arm directs these men. The agreement made with the provincial Government in regard to issuing permits for burning covered this district also. On account of the large number of settlers in this country a considerable portion of the rangers' time was occupied with this work.

A rangers' meeting was held at Salmon Arm at the close of the fire season at which matters of general interest to the rangers were discussed.

The fire season of 1912 in the Salmon Arm district was very favourable, there being well distributed precipitation all through the season. As a result fires were few and did little damage. Forty-two fires were reported during the season. Following is a list of the causes:—

1. Lightning	18
2. Unknown	12
3. Locomotives	8
4. Campers	4
Total	42

The total cost of these fires was $873.43.

RAILWAY COMMISSION CO-OPERATION IN FIRE PATROL ALONG RAILWAY LINES.

Following requests from the Dominion and Provincial Forest Branches, the Board of Railway Commissioners for Canada gave a hearing on the question of fires along railway lines, and as a result issued Order 16,570, in which are incorporated regulations governing the operation of railways with respect to fires. This order left the carrying out of the regulations to the chief fire inspector. The method pursued by this official was to co-operate, wherever possible, with forest officials. At a conference held by him with the district inspector in Victoria early in June, the requirements of the main line of the Canadian Pacific railway in British Columbia were taken up. These were later incorporated in a letter to the Canadian Pacific railway requiring certain patrols to be established which should cover the entire right of way at least twice each day.

The details of these patrols varied according to the nature of the country and the condition of the right of way. Where the fire hazard was high, a speeder patrol was put on, and where the danger appeared less the work was allowed to be done by the regular force of track-walkers, bridge and snow-shed watchmen and sectionmen.

These patrols were put on within a reasonable time by the railway company. Fortunately, owing to the favourable fire season, their efficiency was not put to any great test, but at any rate no fires occurred starting fro mthe right of way after the establishment of these patrols.

In accordance with the new policy decided upon last season, viz., the burning of oil as fuel on the British Columbia division, the Canadian Pacific railway commenced the conversion of coal-burners into oil-burners.

This was effected completely on locomotives operating between Kamloops and Revelstoke and partially on those between Revelstoke and Field.

This change, eliminating, as it does, locomotives as a source of fire will mater ially reduce the fire hazard. Another factor which operates as a source of fire from railway lines is the throwing of cigar or cigarette stubs and lighted matches from trains. People using the observation platforms are special offenders in this regard.

If the railway company could be induced to take steps to educate the travelling public to the consequences of their thoughtlessness, great saving would result to the railway company, to the Department, and to the public at large.

The district inspector at Kamloops was appointed by the Board of Railway Commissioners as fire inspector for the railway belt to enforce the order and the requirements of the chief fire inspector on lines of the Canadian Pacific railway within the railway belt of British Columbia.

To assist in this work the board also appointed two other officers of the Forestry Branch to act as divisional fire inspectors under the direction of the fire inspectors for the railway belt. These two men spent their entire time going over the line, getting in touch with the railway officials and the patrol force, and reporting on the efficiency of the work performed.

These officers also submitted reports covering the right of way, which was in many cases in a very unsatisfactory condition. As a result of action taken on these reports, considerable improvement has been made in the condition of the right of way, and in two cases at least special contracts have been let by the company in the spring of 1913 to clear up the worst places. It is hoped that by consistent efforts on the part of the inspectors and the board, the company will decide to put the whole right of way in first-class shape.

Respectfully submitted,

D. ROY CAMERON,
District Inspector.

APPENDIX No. 5.

REPORT OF INSPECTOR OF FIRE RANGING.

FORESTRY BRANCH,
OTTAWA, February 18, 1913.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa, Ont.

SIR,—I beg to submit the following report on matters pertinent to fire protection in the provinces of Manitoba, Saskatchewan and Alberta, on such timbered portions of the public domain as have not as yet been included in forest reserves.

In the matter of fires the Branch has been exceedingly fortunate during the past summer; this to a great extent has been due to the wet weather conditions which prevailed pretty generally over the three provinces. With the exception of Northern Alberta, in the Peace River district and to the north of it, there was abundant precipitation from the first week in July until well on into the autumn; but the fact that even under such conditions a great deal of vigilance is required is exemplified by the table of fires recorded later on in this report. The comparative immunity from fires is due also to the fact that there is now excellent legislation for the protection from fires along railway lines.

As my work fell into two distinct classes I shall use these subdivisions as a basis for my report.

FIRE PROTECTION ALONG RAILWAY LINES.

Through the recent order (No. 16570) of the Board of Railway Commissioners, the various railways under the jurisdiction of the Board are now compelled to take certain precautionary measures for the prevention and extinction of fires along railway lines. These measures may be briefly enumerated as follows:—

1. Use of fire-protective appliances.
2. Non-use of lignite coal.
3. Proper supervision of tie-burning.
4. Clearing right of way.
5. Ploughing fire-guards.
6. Establishing of a special patrol force.

With all but the fifth of these measures the Branch is deeply concerned, and a few words with regard to them might appropriately find place here.

1. *Appliances.*—This section provides for efficient spark-arresters and ash-pan screens. Formerly a great many fires were caused because such devices were either very inefficient or entirely lacking, and as a result many fires were started by live sparks and ashes. Although the devices now prescribed cannot be said to be an absolute safeguard against fires, certain it is that fires from this source have greatly decreased in number, and, owing to a competent inspection through the officers of the operation department of the Board, the tendency of the engineer to destroy the screen, to allow for greater draft, has greatly decreased.

2. *Lignite Coal.*—The various companies have issued strict instructions forbidding the use of lignite coal, and, although an occasional load does find its way into the tender, such occurrences are comparatively rare. The district inspectors are constantly on the lookout for such coal being used, and one or two good instances detected and penalized should create an absolute observance of this section.

3. *Tie burning.*—The companies are still somewhat lax in the matter of disposing of old ties, and in one or two instances I have observed indication which would lead me to suspect that fires have started from this source, although such imputation was strongly repudiated by the sectionmen concerned. There is, however, a great improvement over the carelessness which was formerly exhibited in this respect.

4. *Right-of-way clearing.*—Early in the season, when I went over the various lines, I found that in many places the right of way was in a most deplorable condition, there being in many places large quantities of inflammable weeds, brush and woody debris. I took this matter up with the companies concerned, but, presumably on the plea of scarcity of labour, little was done till late in the season, when a hearing before the board accelerated matters considerably. There is still much to be done, however, and it is hoped to get all the lines in good condition before the coming season progresses very far.

5. *Construction of Fire-guards.*—This section is designed largely for the prevention of prairie fires, and, inasmuch as fire-guards are more or less impracticable in a wooded country, it does not apply to timbered land, except, perhaps, in places where a prairie fire might enter into and destroy timber.

6. *Establishment of a patrol force.*—In this section the officers of the Branch are particularly interested, for herein lies the real solution of fire protection along railways using coal fuel. Owing to the large number of fires which have occurred along railway lines, it was formerly necessary for the Branch to provide its own rangers to contend with this fire evil; but now, with the compulsory establishment of a patrol force by the company itself, operated and maintained by the company, the Branch is not only relieved of a financial outlay which is not rightly its own, but has a body of men working under the supervision of the railway officials, and perhaps there is no organization so well fitted to efficiently handle such a staff of men as a railway company.

Practically speaking, but two companies in the territory under my administration are required to establish special patrols; these are the Canadian Northern and the Grand Trunk Pacific Railway Companies.

On lines under operation, the Canadian Northern railway had some 21 men exclusively engaged in patrolling such parts of the companies lines as traversed timbered land. Of these, four were in southeastern Manitoba; three between Dauphin and Swan river, to the east of the Duck Mountain Forest Reserve; seven between Swan river and Crooked river; two on the Hudson Bay line from Hudson Bay Junction to Pas; and five were in the vicinity of Prince Albert. All of these men patrolled the line by means of velocipedes and each man had approximately twenty miles of line over which he was obliged to make a return trip each day.

In addition to the men prescribed for lines under operation, a patrol was prescribed on such portions of the lines under construction along which patrols were considered necessary. West of Edmonton, beyond the Pembina river, a patrol of one man was prescribed for each ten miles of line.

The Canadian Northern patrol service was very satisfactory indeed, and many fires were prevented in their incipiency. The experience of the past summer is certainly such as would warrant a continuation of the patrol service, and it has been found that, for average conditions on a track where there are no excessive grades, one man can, with a velocipede, quite satisfactorily patrol twenty miles of line.

On the Grand Trunk Pacific railway west of Edmonton, from Wabamun to the summit of the Yellowhead Pass, some men were prescribed, but this company was very dilatory, and, in fact, did not comply with the order of the chief fire inspector at all, until, in October, a very modified patrol of two men on motor-speeders, from Gainford to Prairie creek was established. On the Grand Trunk Pacific line from Winnipeg east to the Ontario boundary the country was so wet that I relieved them from patrol over that line.

So much for lines subject to the jurisdiction of the Board and affected by Order 16570. Along the line of the Hudson Bay railway, now under construction from Le Pas northeastward toward Hudson Bay, we had men working under the direction of Mr. A. McLean, our chief fire ranger at Pas. These men patrolled the line on foot and aided by the prevailing wet conditions no serious fires are reported.

INSPECTION WORK.

To provide for adequate inspection of the actual work done by the railways in compliance with the order, I was appointed an officer of the Board (fire inspector), with the powers delegated by that body to its officers. As the territory under my jurisdiction is a very large one, and as I have, moreover, my work away from railway lines, I appointed three of our best fire rangers to act as district inspectors for me, Messrs. Thos McNaughton, E. Tennant and A. C. Smith, located at Prince Albert and Hudson Bay Junction in Saskatchewan, and at Wabamun, Alberta, respectively. I may say that these men carried on a very efficient inspection, and it was due largely to their efforts that I was able to keep thoroughly in touch with the work all over the country, Mr. McNaughton, in particular, showed marked capabilities in this inspection work which will doubtless be recognized by his being given greater responsibility.

The following table summarizes the number and causes of fires along the railways during the season:—

FIRES ALONG RAILWAY LINES.

District.	Causes.			
	Locomotives.	Sectionmen.	Clearing Right of Way.	Travellers, tramps, &c.
S.E. Manitoba	18	2	1	1
Dauphin	7			
Hudson Bay Jct. and Pas	11	1	2	1
Prince Albert	24			2
Edmonton	26	4		4
Totals	86	7	3	8

FIRE PROTECTION OUTSIDE OF RESERVES.

For the administration of fire protection on licensed and other forest lands not included within forest reserves, the whole territory under the Branch's administration is divided into eight large districts, designated as follows:—

1. Southern Manitoba.
2. Northern Manitoba.
3. Pas.
4. Prince Albert East.
5. Prince Albert West.
6. Battleford.
7. Edmonton.
8. Great Slave.

Each of these districts is under the supervision of a chief fire ranger. In some cases the sole work of the chief fire ranger is in administration of the fire-protective service, while in others the work has been combined with the duties of timber inspection. The time has come when there should be in every district a man whose whole time shall be devoted to the fire-protective work alone, and this step, which will doubtless result in improvement, is being effected for the coming season.

Acting under the direction of the chief fire ranger in each district there is a staff of fire-rangers, varying in number according to the size and nature of the district. These men are directly responsible to the chief ranger and all reports are submitted through him. These men patrol the country by various means, posting notices and advising people as to the dangers of, and the law concerning, fires, and put out as quickly as possible such fires as do occur.

In all the Branch had some 130 fire rangers employed during the fire season, of these probably 100 were employed continuously from May till November.

As conditions vary so greatly I shall take up the work district by district:—

Southern Manitoba.—Included in this district is the forested land in the northern half of the peninsula between lakes Winnipeg and Manitoba, the area east of the southern portion of lake Winnipeg, and the strip of forest country stretching from the mouth of the Winnipeg river in a broad belt east to the Ontario boundary and southward to the International boundary west of the lake of the Woods. The dangerous parts of these areas were patrolled by a staff of six men.

In the southeast corner of the province are located timbered areas which are essentially valuable as a source of fuel wood; lumbering is also carried on to a limited extent. The same may be said of the northern part of the peninsula, where there is perhaps, more large timber. In view of the fact that the cordwood industry is considerably developed, and so many obtain a livelihood through such operations, it is essential that the forest be protected. The district which each ranger has to cover is a large one, but the problem here is that of keeping under control the setting of fire by settlers.

There is a vast forest area east of lake Winnipeg which is as yet practically unexplored and about which comparatively little is known; but recently there has been an influx of prospectors up the various water-courses flowing into the lake from the east. There are vague reports of the occurrence of large fires on this area and it behoves the Branch, therefore, to take steps in the immediate future for the establishment of some measure of protection.

On the areas under patrol there have been very few fires indeed, the season being very wet and the danger of fire not great. About the only fire which did any damage at all occurred on the spur line of the Canadian Northern railway near the boundary, and burned over some 500 acres of cordwood land. The cause of the fire was carelessness in right of way clearing.

Northern Manitoba.—This district embraces an immense stretch of lake country from the foot of lake Winnipeg down the Nelson and its affluents to Port Nelson on Hudson bay; also to the east, the valley of the Hayes river and the lakes along its course. On this great area of forested country there were some twelve men, supervised by Mr. Blackford, the chief ranger. Although I was unable to visit the district last year we may feel sure from Mr. Blackford's reports that he is keeping up his good work among the Indians and other people in that country. Mr. Blackford informs us that no serious fires have, to his knowledge, occurred in the district during the past year.

Several observation made by Mr. Blackford in one of his reports are interesting, and serve to accentuate the necessity of intensifying the patrol work in his district. Worthy of particular attention are the following:—

(1.) That the possible growth of merchantable timber in this country has not been overestimated, but rather the opposite.

(2.) That fully 70 per cent. has been burnt in comparatively recent times.

(3.) That 40 to 50 per cent is again growing up to spruce, jackpine, poplar, birch and tamarack, in the order named.

(4.) That the Indian, through thoughtlessness, not carelessness, has been the cause of a large number of fires.

(5.) Water routes leading out of Norway House, and constantly travelled on more or less, approximate 1,500 miles; and it is impossible with the present number of rangers to do more than patrol the main routes.

Pas.—This district embraces the country within a radius of a hundred miles or more, east, north, and west of Pas, Manitoba. This country, also, has been but little explored until very recent years. But now, with the construction of the Hudson Bay railway, people are pouring into the country, and the danger of former years is increased tenfold. The country is for the most part flat, and there are very extensive muskegs and spruce and tamarack swamps, in places rising up to low poplar ridges. The timber is, on the whole, of comparatively small size, such areas of good sawtimber as exist being almost wholly confined to the main water-courses and lakes. However, the timber is of sufficient importance that vigourous steps should be taken to protect it. Owing to the swift currents of the rivers the country is rather difficult to patrol. There were, however, seven men continuously engaged in this work, four of these, as previously mentioned, being on the Hudson Bay railway right of way.

The area reported by the rangers to have been burnt over in this district approximates forty square miles, almost no damage having been done to merchantable timber; indeed the damage reported is said to be slight. In all probability, however, much young growth was destroyed which (although it is hard to make people realize it) has considerable potential value. In addition to this damage there are rumours that a large fire occurred to the northwest, far beyond the reach of our outposts. This signifies that here also the Branch must extend its efforts farther north.

In order to make it more possible for the chief ranger, Mr. McLean, to make rapid inspections, a fine new 35-feet motor boat has been built and is ready for work during the coming season.

Prince Albert East District.—The district includes the country on both sides of the Canadian Northern railway from Hudson Bay junction west to Tisdale, north to the Saskatchewan river, and south for some 35 miles. It is an area of frequent muskegs, but there are many ranges of hills on which there are large amounts of splendid spruce. That it is a lumbering country is emphasized by the fact that practically every town or village along the line of railway is the centre of some lumbering industry.

The district was patrolled during the summer by a staff of rangers varying in number from eight to fourteen men, all in charge of Mr. H. Browne, Crown Timber

Inspector, at Melfort. The town of Melfort is situated well out on the prairie and it is essential for the centralization of administration that the headquarters be moved to Hudson Bay junction.

It is reported that not more than thirty square miles of country were burnt over. the damage being for the most part confined to young growth.

Prince Albert West District.—The district embraces the country for some eighty miles north to Montreal lake, on the east, west for ninety miles and north to the Beaver river. It may be divided into three parts:—(1) The more settled portion just north of the Saskatchewan river for 20 or 25 miles, where roads offer an easy means of travel from point to point, but where, owing to the large amount of absolute forest land interspersed with good agricultural land, it is necessary to have an effective patrol to protect young growth on reserves and cordwood areas, and also to prevent, if possible, the spread of fire to the more timbered area to the north; (2) the area just to the north of this, where roads are scarce and travel difficult, a district where settlers are few and where fire is a constant menace to the forest resources; and (3) a vast lake country with large quantities of timber, where practically the only means of travel is by canoe or on foot.

On the whole of this area we had sixteen rangers, nearly all being engaged from May till November, under the supervision of Mr. Jos. Coombs, Timber Inspector.

In this district more damage was done to merchantable timber. Approximately 600 square miles of the country were burned over. One fire of unknown origin which occurred away to the north, just southwest of Lac la Plonge, is said to have run over 20 square miles and to have destroyed 60,000,000 feet, board measure, of merchantable timber. It is true that dues on this timber would amount to only $30,000, but this timber would have been worth many times this amount to the country if it could have been saved; it is a dead loss, because it is altogether improbable, if not impossible, that the burnt timber can be salvaged prior to its destruction by borers and fungi. The loss in this one fire alone is several times greater in amount than the appropriation for fire-ranging in the whole Prince Albert district. Extensive fires of this nature have occurred in the district north of Prince Albert for many years, due in part to carelessness on the part of the Indian and half-breed populace, and also to a transient population of surveyors, explorers, prospectors and trappers. Owing to the sparse population it is impossible to do much with a fire when once it is well started, and every step should be taken for the prevention of such fires, for not only does the country offer fine opportunities to the lumber industries, but also on account of the extensive poplar and spruce areas and the presence of water powers, ventures into the pulp industry would probably meet with encouragement and success if a fair amount of stability and safety were secured.

Battleford District.—This district is very similar to that described for Prince Albert West, except, perhaps, that there is a more distinct line between the prairie and the timber belt; for this reason it is most important that a thorough patrol along the verge of the settled country should be maintained.

The northern part of the district is much broken by numerous lakes and rivers, and in it there are extensive areas of spruce saw-timber, cordwood and pulpwood. Water powers, too, are numerous, and hence the same possibilities for pulp manufacture are presented, though perhaps to a more limited extent than in the Prince Albert West district.

A staff of only six men patrolled this district, and owing to the great extent of country it will be necessary to considerably augment these forces if good fire protection is to be secured.

Nearly 500 square miles of the country were burned over, but the fires are reported as having been confined to grass-land, muskeg and scrub, with little damage done to merchantable timber. There were 21 fires involved in this burning—9 caused by

campers, 3 as a result of careless burning, and 9 of which the causes were unknown. The rangers in this district were particularly good men, and I feel sure that had it been possible for them to arrive at the probable causes of the latter they would have done so. This merely accentuates the necessity of having more men to prevent these 'unknown' fires.

Edmonton District.—This is a very large district, embracing as it does the country from Red Deer and Rocky Mountain House north to, and including, the Peace River district. This area is, of course, by no means all timbered; in fact, the southern part is very well settled, but there are large stretches of absolute forest land on which there is a good forest-cover established. The country has in the past been repeatedly swept by large fires, but by additional patrol there is no reason why these fires could not be greatly reduced, if not almost entirely eliminated.

Patrolling over this area we had 58 rangers in all, of which only 30 were retained for the greater part of the season. This was a great improvement, in point of numbers, over the staff of previous years, an improvement which was due to the fact that Mr. R. H. Palmer, chief ranger of the district, travelled over the greater portion of this immense territory, appointing men where he thought it necessary to do so.

In spite of the fact that the fire protective force comprised more men than in previous years, the magnitude of the country forces these men still to confine their attention to the main trails and waterways, as it is along such avenues of travel that the majority of fires are started. Owing to the great influx of settlers to the north, intent on settlement in Grand Prairie or Peace River, (the tide of settlement being far greater than that to the north of Manitoba or Saskatchewan) it will be necessary for the Branch, in the near future, to still further add to its staff if it means to have good protection.

From Athabaska Landing the only way to the north is down the Athabaska river, in summer by boat, canoe or scows, in winter by dog train. Practically all ingoing people have to camp on the shores of the river at night, and, therefore, here lies the chief danger. To contend with this, we have a stern-wheel patrol boat continuously engaged in patrolling the river from the Landing to Grand Rapids. The boat is manned by four men, who, in addition to operating the boat, are official fire-rangers.

In the Edmonton district an area somewhat less than 300 square miles was burnt over, the damage consisting chiefly in the destruction of young growth, comparatively little merchantable timber having been destroyed.

One of the main problems to be faced here, is the progress of railway construction; in nearly all directions lines of railways are projected, and several are actually under construction. Along these lines travellers are continually passing—not only railway men, but others also, intent on various pursuits. Not only are fires caused by such persons, but the actual process of clearing the line, by the use of fire, constitutes a serious menace, and as a result the fire-protective force has to concentrate its attention along, and in the neighbourhood of, such lines.

Great Slave District.—This embraces the Athabaska River for over a hundred miles below Grand Rapids, the Clearwater river east to the fourth meridian, and the Lac la Biche trails. In this district the patrol was organized and has since been supervised by Mr. Conroy, of the Indian Department. During the past year seven men were employed as rangers, plying up and down the rivers above named. With regard to fires in this district an area of altogether 85 square miles was burnt over, entailing a loss of 20,000 feet, board measure. In addition to this a considerable number of fires were extinguished in their incipiency; these fires were for the most part, attributable to neglected camp-fires of travellers or wandering Indians.

Speaking generally for the whole country above referred to, approximately 1,000

square miles were burned over as a result of some 480 fires. The causes to which they are attributable, in numerical order, were as follows:—

Causes.	Number.
Campers, surveyors, prospectors, &c	138
Careless clearing of land	108
Locomotives	86
Sectionmen	7
Deliberately lighted	5
Clearing railway right-of way	3
Lightning	2
Causes unknown	131
	480

An analysis of this table is almost superfluous; it is easily seen that though a change of attitude on the part of the general public is coming about, campers, prospectors and surveyors still persist in carelessness with regard to fire, that settlers are, by the careless use of fire in clearing land, still responsible for a very large number of fires. In 1911 the greatest number of fires was attributed to railways, while in 1912 they stand third in the list of known offenders.

The experience of the season also shows that in spite of abnormally wet weather conditions it is quite possible for fires to occur, and that, therefore, we must be constantly vigilant in order to arrest the progress of serious fires. As a matter of fact, there were actually more fires reported during 1913 than in the previous year, although the damage is considerably less. This greater number is probably due to a more efficient reporting of small fires, rather than to the actual occurrence of more fires.

One of the greatest difficulties in promoting a proper regard for the law is the deficiency in the fire laws of the three provinces; under these laws it is almost an impossibility to get an offender convicted and properly punished, owing to the loose interpretation of the law by rural judiciaries. It is hoped, however, that the legal departments of the provinces will awake to the necessity of efficient, up-to-date legislation, so that the forestry officials will not be so handicapped in their campaign to reach an ideal, to secure a proper observance of the intentions behind all fire laws, viz., *prevention of fires.*

Another direction in which there ought to be a great improvement is in the work carried on by the provincial governments in the construction of roads. Nearly every provincial road through forested land constitutes a veritable fire-trap; brush and slash are piled at the side of the clearing and left to rot, solely to avoid the expense of removal by careful burning. Not only is such slashing unsightly, but it forms more or less of a magazine into which some unwary traveller may throw a cigar or cigarette stub and give rise thereby to a serious fire. This neglect by its example also weakens the effect which it is intended that the law should have on the people. How can a settler be expected to cheerfully obey the law in regard to exercising due care when before him may be a monument of carelessness and neglect in the construction of roads?

In carrying on my work of inspection I visited each district, meeting as many of the individual rangers as it was possible for me to do. A great deal of my time was taken up in getting things running smoothly along railways, and I firmly believe that the experience of 1912 (when we were favoured by Providence with an easy season in which to start) in work along railway lines will pave the way to efficient fire-protection along the various lines of railway operating through timbered lands.

In the protection of licensed lands I fully believe that the lumbermen concerned should be called upon to recommend men to act as fire-rangers. The lumbermen have the most at stake, and would see to it that such men would be recommended by them as could be implicitly relied upon to carry on such work. The lumberman in the three western provinces hire their men for the winter only; the men are real woodsmen,

and would be glad to officiate as rangers for a remuneration considerably less than is paid at the present time by the Branch.

In Ontario and Quebec this system has been worked out on licensed lands with the result that a most efficient fire-protective service has been developed.

E. H. FINLAYSON,
Inspector of Fire Ranging.

APPENDIX No. 6.

REPORT OF RECONNAISSANCE SURVEY IN COAST DISTRICT OF BRITISH COLUMBIA.

Forestry Branch,
Ottawa, October 22, 1912.

R. H. Campbell, Esq.,
Director of Forestry,
Ottawa, Ont.

Sir,—I beg to submit herewith my report on the work which I have carried on during this season with the object of determining the boundaries of a forest reserve to be situated north and west of the Fraser river in the Coast district of the Dominion railway belt.

Accompanying this report is a general map showing the location of the boundary lines, and also a number of township maps on which has been roughly sketched the topography of the country surrounding the line. The Coast District, as considered in this report, is the part of the railway belt that lies between Keefer's (on the Canadian Pacific railway) and the Pacific Coast—a territory approximately 40 miles wide and 130 miles in length.

TOPOGRAPHY.

The Coast District is very mountainous, the only low land being found in the southwestern part of the railway belt in the lower Fraser valley. The mountains usually reach an altitude of from 4,000 to 6,000 feet, but peaks from 7,000 to 9,000 feet high are not uncommon. The many large lakes and the numerous rivers and creeks which cut across the ranges give to the country a very broken appearance.

Through the centre of the Coast district flows the Fraser river. Between Keefer's and Hope the Fraser valley is quite narrow with steep, rocky, often precipitous mountain slopes, either breaking abruptly into the river, or at best forming a narrow bench before taking the final plunge into the river. At Hope the valley begins to widen and the river changes from a raging torrent to a swift, wide river, which at Harrison becomes navigable for large river-steamers. At Agassiz the river enters the flat or slightly rolling, fertile, alluvial lands of the lower Fraser valley, a territory containing approximately 700 to 800 square miles of arable land and constituting the only compact stretch of agricultural soil in the Coast District.

Practically all of the many rivers and creeks which drain the Coast District contribute directly or indirectly to the supply of water in the Fraser river. They could appropriately be divided into three classes:—

1. Navigable rivers.—Pitt river, Harrison river.

2. Non-navigable rivers.—(100 feet wide or more, with an average fall of less than 100 feet to the mile):—Coquitlam, Lillooet, Stave, Chehalis, Coquihalla and Nahatlatch (or Salmon) rivers.
3. Creeks.—(less than 100 feet wide and generally with a fall of more than 100 feet to the mile):—
   All other water-courses in the Coast District.

The valleys of these rivers and creeks are comparatively deep and narrow, the forces of stream erosion and weathering not yet having had time to develop the broad open valleys found in regions of more ancient formation and softer rocks.

Many of the river valleys in the Coast District have, through glacial action or other accidents, been in part transformed to lakes. These lakes, of which the largest are the Harrison, the Pitt and the Stave, are surrounded by high mountains generally sloping steeply down to the water, forming very few flats or benches.

AGRICULTURAL RESOURCES.

As can be gathered from the above, there is comparatively little land susceptible of tillage in the Coast District. We have:

(1.) The above-mentioned fertile lower Fraser valley;

(2.) The lower moderate slopes of the mountains bounding this valley on the north between the Coast and Dewdney (48 miles east of Vancouver), and

(3.) Narrow strips along some of the rivers or on benches.

Most of this land has already been thrown open for settlement.

The portions of the railway belt which lies north and west of the proposed forest reserve line, and which is bounded on the west side by the North arm of Burrard inlet, is at present more valuable for the growing of timber than for farming of any kind. There are no compact bodies of agricultural land of large extent. A few acres of level or fairly level land with good soil may be found along streams, on benches, on lake shores or at the confluence of streams, but rarely of sufficient area to raise enough produce to support a family in decency.

And, further, good soil and suitable topography are not the only factors that the homesteader has to consider; climate and market conditions must also be favourable to secure the success of the farmer.

To exclude from the proposed forest reserve at the present time a few acres here and a few acres there of agricultural land—now covered with timber—would hardly be practicable. In the future, however, when a thorough examination has been made of the forest reserve and the exact boundaries of any agricultural area that may have been included in the reserve have been located, would it not then be advisable to permit bona-fide settlement on this land after the timber has been removed? This has been done in European countries and in the United States. Mr. H. S. Graves, Chief Forester of the United States Forest Service, says in a recent article:—

> 'Bringing settlers into the mountains makes forest administration and protection easier. The Forest Service needs the help of settlers in fire protection. It is obtaining their assistance in many localities through co-operative and administrative force and in the construction of trails and other improvements. Every home-builder in a national forest is an immediate asset in its present administration and future development.'

TIMBER RESOURCES.

The Coast district is chiefly a timber-producing country. I estimate that of its total area, approximately 20 per cent to 25 per cent is under cultivation, or else capable of agricultural development; approximately 15 per cent consists of water, barren

mountain or is land otherwise unsuitable for forest growth; and approximately 60 per cent to 65 per cent is fit only for the production of timber.

It is, of course, not possible to give an accurate estimate of the timber in the Coast district, as only a comparatively small portion has so far been examined. I believe, however, that approximately 25,000,000,000 to 30,000,000,000 board feet would be a fairly conservative estimate; of this 15,000,000,000 to 20,000,000,000 feet could probably be found in the proposed forest reserve.

Douglas fir is the most abundant and commercially most important tree of this region. It is sometimes found in pure stands, but generally in mixture with red cedar (*Thuja plicata*) and Western hemlock (*Tsuga heterophylla*). Other coniferous species sometimes found in groups or scattered are Sitka spruce (*Picea sitchensis*), Western white pine (*Pinus monticola*), lodgepole pine (*Pinus Murrayana*), yellow cypress (*Chamaecyparis nootkatensis*), and Amabillis fir (*Abies amabilis*). At high elevation considerable mountain hemlock (*Tsuga Mertensiana*) and balsam fir (or 'balsam') (*Abies lasiocarpa*) are found.

I estimate that the timber in the Coast district consists of approximately 65 per cent Douglas fir, 18 per cent red cedar, 15 per cent Western hemlock, and 2 per cent of other species.

Douglas fir requires for its best growth a long growing season, considerable atmospheric humidity and well watered soil. The climatic conditions on the Coast are most favourable in this respect. Compare the slow-growing, often crooked or stunted Douglas fir of the interior or eastern British Columbia with the magnificent Douglas fir of the Coast. I have seen lately at a logging operation a timber stick that was 58 inches at breast-height (inside bark), 212 feet long, 17 inches at the top and perfectly sound. I have measured Douglas fir that were only from 150 to 165 years old and 220 to 240 feet in length with a diameter at breast-height of from 50 to 60 inches.

Below is a table showing the average rate of growth for Douglas fir growing in fairly even-aged, well stocked, mixed conifer stands in the Coast district, based on measurements of several hundred trees:—

GROWTH TABLE FOR DOUGLAS FIR ON SOILS OF FIRST QUALITY IN COAST REGION.

1st quality soils.

Age.	D.B.H.	Total Height.
	Inches.	Feet.
10	1·6	7
20	5·6	30
30	10·7	59
40	15·0	82
50	18·9	101
60	22·0	118
70	24·8	134
80	27·5	146
90	30·0	157
100	32·4	166
110	34·6	174
120	36·8	181
130	39·0	187
140	41·2	193
150	43·2	198
160	45·2	203
170	47·0	207

The trees measured were growing on bench-land or moderately steep slopes.

The figures given are too high for trees growing at high altitudes or on very steep, rough ground. My purpose with this table is only to show how short a time really is required in many instances to produce fir timber of large size.

Even other species, especially red cedar and Sitka spruce, attain a very respectable size, but there is no doubt that Douglas fir is, on account of its abundancy, its hardiness, its rapid growth, its power to resist disease and injury from fire, and its many other excellent qualities, the *par excellence* of this region.

Douglas fir has the ability to form dense stands and the yield per acre is, under favourable conditions, immense. Some time ago a lumberman pointed out to me a little flat of three acres which he had logged off. 'I got a million feet there,' he said, and the density of the large stumps vouched for the truth of his statement. Timber cutting 300,000 feet per acre is, of course, far from being an ordinary occurrence, but whole stands that will average from 50,000 to 100,000 per acre are not uncommon.

I am afraid, however, that it will not be very long before the best timber is logged off. The lumberman will then have to make use of the more remote forests and the second growth.

There are at present large areas in the Coast district which have been logged off or burnt over and which are now covered with a reproduction or advanced second growth. The ground is not always stocked to its full capacity with seedlings or young trees; neither are the re-stocking species always the most desirable ones. To allow such conditions to continue might have rather serious consequences on the future timber supply. The time when our timber was considered to be inexhaustible is past and it is generally acknowledged that the forests need proper care and protection.

It would, of course, not be practicable at the present time to begin to improve the second-growth stands in the Coast district, but what can and should be done is to see that satisfactory reproduction is established after logging and that the re-stocked areas, as well as the virgin forests, are protected from fires.

Douglas fir is a hardy, vigorous tree; it is a good seed producer and it is a comparatively easy problem to obtain good reproduction after logging. It will be necessary to clear-cut, in some instances, leaving a few seed trees on the cutting, and burn the slashing. This will, of course, involve expense. There is no question, however, that this cost will not be outweighed by the increase in annual growth which, no doubt, will be the result of systematic management.

I have not as yet prepared any yield tables with reference to Douglas fir stands in various soils in the coast district. I have, however, studied the growth of the species on the coast rather closely, and from the knowledge I have gained, I feel justified in using the yield table given below for even-aged stands of Douglas fir in the western foothills of the Cascades as an example of what can be done in the way of growth on the best soils in the coast district. This table is borrowed from 'The growth and management of Douglas Fir in the Pacific Northwest,' (United States Forest Service Circular No. 175, by T. T. Munger). The climatic and topographical conditions of the British Columbia Coast District are very similar to those of Western Oregon and Washington. It must be remembered, however, that Mr. Munger's yield-table refers only to stands growing on first-quality soils.

YIELD FOR EVEN-AGED STANDS OF DOUGLAS FIR ON FIRST-QUALITY SOILS, WESTERN FOOTHILLS OF THE CASCADE MOUNTAINS IN WASHINGTON AND OREGON, READ FROM CURVES.

(Based on 252 $\frac{5}{16}$ acres, 361 sample plots.)

Age.	Number of trees per acre.	Total basal area.	Diameter of average tree.	Height of average tree.	Yield per acre.*	Average annual growth per ac. in each decade.	Yield per acre*	Average annual growth per ac. in each decade.
Years		Sq. Ft.	Inches.	Feet.	Cu. Ft.	Cu. Ft.	Feet B. M.	Feet B. M.
10	.....	....	....	....	1,000	....	....	....
20	990	116	4.6	32.0	2,150	115	....	....
30	580	147	6.9	46.0	3,550	140	....	....
40	410	177	8.9	59.0	5,400	185	12,400	....
50	340	199	10.4	69.5	7,550	215	28,000	1,560
60	265	218	12.3	82.0	9,650	210	41,000	1,300
70	298	234	14.4	95.0	11,500	185	51,700	1,070
80	167	247	16.5	107.5	13,100	160	61,100	940
90	137	261	18.7	120.5	14,400	130	70,300	920
100	115	275	20.9	134.5	15,600	120	79,800	950
110	100	288	23.0	147.0	16,750	115	90,300	1,050
120	92	301	24.5	156.5	17,800	105	101,500	1,120
130	90	312	25.2	161.0	18,850	105	113,000	1,150
140	88	323	25.9	166.0	19,900	105	122,600	960

Note—Including only Douglas fir, western hemlock, grand fir, and Sitka spruce; over 95 per cent of the trees are Douglas fir.

*The yield in cubic feet includes the contents of the whole stem of all the trees; that in board feet includes only the merchantable contents of trees 12 inches and more in diameter at breast height, taken to a top diameter of 8 inches inside the bark.

GRAZING.

Owing to the dense undergrowth in the coast forests there is little or no land suitable for grazing purposes to be found inside the proposed forest reserve.

WATER-POWER RESOURCES.

British Columbia is immensely rich in rivers and streams capable of producing water-power. Especially has the coast district been well favoured. It is very probable that at least 250,000 horse-power can be produced in the Coast district alone. Of this approximate total, about seventy or eighty thousand horse-power already are being utilized by the Vancouver Power Company at Lake Buntzen and the Western Canada Power Company at Stave Falls.

Everyone knows, without discussing the subject, the relationship between water-powers and forests, and all know that a staple water-flow in streams and rivers is largely dependent on the maintenance of a permanent forest-cover on the watersheds.

In conclusion, I most urgently recommend that a forest reserve be established north of the Fraser river as proposed. The creating of a forest reserve would mean, first and foremost, better fire protection. Better fire protection means the conservation of timber resources, conservation of water resources, and maintenance of a staple water-flow in the rivers and streams . All this combined means more money to the gov rnment and more money to the public.

Respectfully submitted,

H. CLAUGHTON-WALLIN.

APPENDIX No. 7.

REPORT OF RECONNAISSANCE SURVEY IN VICINITY OF PORCUPINE RESERVES.

FORESTRY BRANCH,
OTTAWA, Dec. 5, 1912.

R. H. CAMPBELL, Esq.
Director of Forestry,
Ottawa, Ont.

SIR,—I beg to submit the following report of work carried on by me during the past season in surveying reserve boundaries in Northern Manitoba and Saskatchewan.

In accordance with instructions received May 18, I left Ottawa on May 22 for Swan River, Manitoba, being joined *en route* by Mr. W. J. Boyd, my assistant. On arrival at Swan river it was found that Pelly, Sask., would be the most suitable point from which to begin work, and on Tuesday, June 11, after a number of delays due to bad weather, the party left Pelly.

OBJECT OF THE SURVEY.

The object of the survey was to locate the boundary of an addition to the present Porcupine Forest Reserve and to collect any information possible regarding the interior of the proposed addition.

The season was one of the wettest on record and the party lost a great deal of time on account of rain. The country also was so saturated with water that trails were often impassable and travelling was consequently much impeded. The following table shows the number of rainy days per month from the time the party reached Pelly:—

June	4
July	24
August	13
September	17

The season was decidedly one of extremes, very high temperatures were noticed in June while frost nights occurred every month the party was out.

On September 16, Mr. Boyd left for college and from that time till October first I worked alone. From October 7th until the completion of the work (October 25) I was assisted by Mr. E. Tennant, the Hudson Bay Junction fire-ranger.

During the earlier part of the season the party travelled by means of a pack-train, the daily work being done on foot. Later on, however, owing to the open nature of the country, we were able to substitute a wagon for the pack-horses and did most of the work from the saddle. The northern boundary was traversed by means of a track velocipede kindly loaned by one of the fire-rangers.

The reserve as now outlined covers an area of about 4,076 square miles, being surrounded by a boundary line over 360 miles in length. The whole stretch of country embraced by this line may be considered as of no agricultural value, being best suited to the purpose of growing timber and conserving the water-supply of the surrounding country.

DESCRIPTION OF RESERVE BOUNDARY.

In locating the boundary line of the new addition to the Porcupine Forest Reserve I took into consideration the soil, the topography, the forest growth and the water conditions with their relation to the surrounding country.

In proceeding north from the Thunder Hill branch of the Canadian Northern railway, it is noticeable that between townships 36 and 38 in ranges 1 to 10, west of the second meridian, a distinct change takes place. The tree-cover, formerly very scattered or altogether lacking, becomes very dense, both poplar and spruce; the surface gets rougher and the percentage of swamp becomes very great, as much as sixty or seventy in some townships. The character of the soil also undergoes a change, the usual soil along the south boundary of the reserve being a cold, grey, stony clay.

Along the west side of the proposed area the line of change from good to non-agricultural land is also clearly marked in most places, while along the north line of the Prince Albert branch of the Canadian Northern railway the poor country extends unbroken on both sides of the track.

In discussing the country bounding the new reserve I will start at the southeast corner, mentioning first the area described by Mr. Van Dusen in his report as 'Area B'. This area slopes slightly to the south and contains a large percentage of muskeg. It rises in township 36, range 32, west of the principal meridian, and then slopes gradually to the south again. The part of the area which is close to the newly located boundary is burned over, and the surface is rough, and cut up by ravines, pot-holes, &c. The soil is brown clay, full of boulders. Farther north towards the old reserve the country is much the same; uneven and badly drained with stony clay soil. I agree entirely with Mr. Van Dusen in his recommendation that this country be set aside. As you will see from my map I have extended my bounds considerably below the point suggested by him, but I am certain that the whole of this area will never be claimed for agriculture.

Below the reserve boundary the country rapidly changes to undulating prairie and scrub land, which is being rapidly settled up. From the second meridian the line is carried west to the Swan river through a heavy bush country badly cut up with spruce and tamarack muskegs and deep sloughs.

With the exception of the South Etomami river, which has sand prairies along its banks, the country from the upper Swan river to the head of the Assiniboine river is all the same. It appears to have been burned over between twenty and thirty years ago, and poplar is established wherever possible. The area is 60 to 70 per cent sloughs, lakes and muskegs, while the narrow ridges are extremely stony, with cold, grey soil. As one goes north from the boundary selected, he finds larger poplar, but otherwise the country is the same with great muskegs and narrow stony ridges.

Along the upper end of the Assiniboine river some prairie land has been included in the reserve, but this was done after considering the small areas of these patches of open land and the fact that they were surrounded by useless country.

In township 38, range 9, a large muskeg occurs, and as the country to the west of this is of good quality, though covered with scrub, it was deemed advisable to turn north here. A large strip of prairie and scrub land was encountered in township 40, ranges 9, 10 and 11, so the line was brought back east to the edge of the poor country in order to leave out of the reserve this area, which has a light sandy-loam soil and is sure to be taken up soon.

In township 41, ranges 10 and 11, the Greenwater hills are met with. These hills are very rough and stony, with a number of lakes scattered among them. They slope westward towards an area of valuable land on the Barrier and Red Deer rivers.

From the Greenwater hills to Björk lake the characteristic soil is almost pure sand or sand and gravel. The surface of the country is rough, and cut up with large muskegs and tamarack swamps. North of Björk lake lies a large stretch of spruce country partially cut and burned over. Owing to the roughness of the country and

the large percentage of muskeg existing, this area is much more suited for the growth of timber than for field crops. South of Björk lake the soil soon becomes good, light, well drained, sandy loam and were it not for the awkwardness of access it would all be under cultivation. The remaining stretch of country between Björk lake and the northwest corner of the reserve is almost all muskeg and lake. Where it is dry enough to sustain tree growth there is a heavy stand of large aspen (white poplar), balsam (black), poplar, spruce and tamarack on cold grey clay.

During the summer I gathered as much data as possible concerning the land south of the Prince Albert line of the Canadian Northern railway between Peesane and Roscoe, and it was agreed by all whom I questioned that this country is fit only for the production of timber. However, I was fortuante enough near the end of the season to secure the assistance of Mr. Enoch Tennant, the fire ranger at Hudson Bay Junction, and with him covered nearly the whole of the north boundary line, so that I am able personally to corroborate all the reports I heard concerning this stretch of land. Mr. Tennant is personally acquainted with practically the whole of the new reserve, having lumbered and travelled through it for many years, so that he enabled me to get an accurate idea of the country at a much smaller expense of time than I would have required to accomplish the same work alone.

From Peesane to Hudson Bay junction the country is fairly uniform, mostly covered with heavy bush, aspen (black poplar), balsam (black), poplar, spruce and tamarack. There is a large amount of spruce and tamarack muskeg and a great many sloughs. The soil is irregular, being of good clay loam in places and elsewhere sandy or gravelly. Although this country was surveyed some time ago, there are practically no settlers on it. A few quarters were entered, but have been mostly abandoned, the only remaining homesteaders being close to the saw-mills.

At Hudson Bay junction the soil is pure sand surrounded by muskeg. A considerable portion of this sand is entered, though not for agricultural purposes. In anticipation of the entrance of a railway, a number of speculators have filed on homesteads in order to profit by a rise in prices. Most of those who tried farming in this vicinity have abandoned their attempts.

From Hudson Bay junction to Roscoe the usual type of the country prevails—timber, muskeg and slough; while from Roscoe to Powell the land, with the exception of one small area two miles east of Roscoe, though higher than that to the west, is impossible for agriculture on account of the poor quality of the soil. Bordering the railway track not far from Roscoe, however, there is an area of about six square miles of semi-prairie land having a rich clay-loam soil.

INTERIOR OF THE RESERVE.

It was very difficult during the past season to make many excursions into the interior of the proposed reserve, although I believe I was able to get a fairly accurate idea of it from the Indians and trappers. As far as is known, the tract is nearly all bush and very badly cut up by sloughs and muskegs. Even on foot, devious routes must be taken in getting from place to place and over large parts of the country horses cannot be used at all during the summer.

To illustrate the difficulty of finding dry footing it may be mentioned that the Red Deer Lumber Company, wishing to put a 'tote-road' into their limits some 35 miles south of the Prince Albert line of the Canadian Northern railway, have tried three different routes. The first two they abandoned in despair, while the third one was impassable all last summer and cannot be used until winter sets in.

In the neighbourhood of the Red Deer river, near the proposed west boundary of the reserve, there is some fairly open land. This is nearly all pure sand, best fitted for jack pine, and there is no likelihood of settlers demanding it for homesteading purposes.

Almost in the centre of the reserve, in the top part of township 39, range 5, there is a settler who has been trying to get people to come in and take up the land around him. As far as can be ascertained, the piece of land he has homesteaded is mostly covered with scrub and has a light and stony soil. Various lumbermen consulted were of the opinion that the land was of poor quality and of no great extent.

In the neighbourhood of the south line several pieces of open land were included. The upper reaches of the Assiniboine are bordered by narrow prairies, which soon rise to ridges covered with poplar. The prairies are very small and their soil stony. The few homesteaders who have penetrated as far as the vicinity of the line are very discouraged and contemplate abandoning. The valley of the Assiniboine would provide an excellent range for cattle.

Near the head of the Swan river and situated between ten and twenty miles north of the south line of the reserve lie two open areas of land, known as the Jackfish Prairie and the Rhubarb, or Pee Paw, Plains. These areas of land were both examined, and are of no agricultural value, though suitable for grazing purposes. The soil in both cases is light and the surface nearly covered with boulders. The upper portion of the Swan river in townships 40 and 41, range 1, west of the principal meridian, is flanked by prairies similar to those on the Assiniboine river.

This above mentioned country is well suited for ranching purposes, but it would not be advisable to permit settlers to clear the land owing to fire danger.

Within the limits of the proposed reserve there are a large number of spruce timber-berths, many of them as yet untouched. Besides these berths, there are bluffs of spruce scattered all over the country, too small in extent, however, to merit their being placed in limits. Except in the space between the Assiniboine and the Swan rivers there is pretty good spruce reproduction scattered through the poplar indicating that the stand will ultimately be largely spruce.

The great quantities of poplar within the reserve are also destined to be of use, as the country a short distance to the south and west has very little timber and soon will be in actual need of a fuel supply.

The species of commercial importance which occur in the country examined are:—

Aspen (white) poplar (*Populus tremuloides*).
Balsam (black) poplar (*Populus balsamifera*).
Tamarack (*Larix laricina*).
Black spruce (*Picea mariana*).
White spruce (*Picea canadensis*).
White birch (*Betula alba*, var. *papyrifera*).

Of these the aspen, or white, poplar is much the most abundant, covering as it does over 50 per cent of the area. The untimbered areas usually consist of slough, lake or muskeg. The former occasionally contain good hay, though more often coarse grass and horse-tails, while the latter are billowy masses of sphagnum moss, sometimes covered with black spruce or tamarack.

CLIMATE.

Mention should here be made of the fact that the whole of this district seems liable to frosts at all seasons of the year, and, consequently, the attempt to grow wheat in it would be accompanied by considerable risk. As mentioned earlier in this report, the past season was very wet and this wetness would have the effect of moderating temperatures. In spite of the dampness, however, frosts were encountered during every month of the season. Experts inform me that a stretch of country subject to slight frosts in such a season as we have had would be liable to severe ones in a normal summer.

TRAILS.

The country examined was, as a whole, badly served with trails, and much time was lost owing to the long detours required. In the neighbourhood of the south boundary there are practically no east-and-west trails, and, consequently, the traveller must come back to settled districts before he can move across country.

The western portion of the country has been for many years the hunting ground of the Indians from the Nut Lake Indian Reserve, who have put trails through all the country west of the Etomami river and south of the Red Deer river. These trails all converge on the old Nut Lake post of the Hudson Bay Company; unfortunately they are usually hard to find, being quite unknown to the white settlers, so that unless one has the services of a good Indian he is unable to take advantage of them.

The northern part of the reserve is penetrated by only a few trails, a railway belonging to the lumber firm of Shaw Brothers, an Indian trail from Greenbush up the Copeau river and Red Deer Lumber Company's 'tote-road' up the North Etomami being the only means of access to the interior of the reserve. Besides these, there is a short Indian trail from Roscoe into the Porcupine Mountain.

In establishing means of communication throughout the country it will not be so necessary to locate new trails as to clean out and repair the old ones. Most of the trails have been well placed and hold to the high ground as much as is possible in such a wet country so that little would be gained in the majority of cases through trying to relocate them. Practically the only entirely new trail which would be required would be one crossing Range 1, somewhere in the north part of Township 37.

WATER COURSES.

The new reserve embraces the sources of a great many rivers and creeks, and for that reason, if for no other, deserves to be protected from deforestation.

The most important of these streams is the Red Deer river, which rises in the Nut lakes just west of the reserve. It has a number of large tributaries, the Fir, the Copeau, the North Etomami, the Pewei, the Little Swan and a number of unnamed rivers, all of which (except the Fir) rise and flow their entire length within the reserve. The Red Deer river leaves the reserve at Erwood, bing at that point about 150 feet wide and from four to six feet deep. At several points along its course the river is very swift and has high banks which would offer an excellent opportunity for the development of water-power.

The rivers flowing south are the Assiniboine, the Swan, the Little Woody and a number of unnamed creeks.

RANGER STATIONS.

In regard to ranger stations there are three points from which fire wardens could work advantageously. One could be placed at Hudson Bay Junction, one near Bowsman or Birch River and one in the neighbourhood of Nut Lake.

The first man would be required to penetrate the country by means of the various trails coming down from the north, the second would reach most of the old Reserve and the newly added southern part, while the third would cover the trails radiating from Nut Lake. The first two men would share the track patrol.

In the mountainous portion of the reserve suitable points for lookout stations could easily be selected, but in the western area there are no outstanding features, so we were unable to locate points upon which towers could advantageously be placed.

ADMINISTRATIVE HEADQUARTERS.

For the Supervisor's headquarters Hudson Bay Junction seems to recommend itself strongly; it is convenient by rail to a great deal of the boundary of the reserve, and the centre of the area is also easily accessible from it. It is rumored that the Canadian Northern railway is to be built from Sturgis to Hudson Bay Junction, in the event of which the advantages of the latter as the seat of the head office, would be greatly increased.

SQUATTERS.

As far as is known, there are only two white squatters within the limits of the new Reserve. One is a rancher on or near Section 35, Township 40, Range 7, and the other is a camp watchman who has a home in the neighbourhood of Section 35, Township 39, Range 6. The former appears to be seriously engaged in raising cattle for the market, but I believe that the latter is principally occupied during the summer watching the Red Deer Lumber Company's camps and engages in agriculture as a side-line.

On the Rhubarb Plains there is an Indian encampment which has been there for many years. These people have not cultivated any land, but live entirely on the proceeds of their hunting and trapping.

GAME.

Owing to the wildness and inaccessibility of the country it is the home of large quantities of big game, the moose, elk, deer and bear all being observed during the summer. Besides these, there is a great abundance of small fur-bearing animals which the Indians have hunted during a great many years. Wild fowl are also plentiful, ducks, prairie chickens and partridges being noticed in great numbers.

ADJOINING TERRITORY.

All the country to the southeast, south and southwest of the new Reserve is arable, being principally gently rolling prairie land with bluffs of poplar and light scrub. The soil for the most part is a heavy, dark, clay loam, which occasionally varies to a sandy loam. This country is penetrated by the Thunder Hill Branch of the Canadian Northern railway and will soon be entirely taken up.

On the west side of the reserve lies the Nut Lake district, one of teh finest stretches of land in the province. North of this district, however, conditions are not quite so good; there is a narrow strip of land suitable for settlement just west of the proposed boundary, but west of this again there are several townships of poor land. I found it impossible to investigate this area, as I was desirous of completing the west boundary of the reserve before winter set in.

North of the Prince Albert line of the Canadian Northern railway and east of Peesane, the muskeg type predominates, although there are a number of stretches of raised country bearing valuable spruce. For the most part, however, the country is very wet and difficult to travel. The soil is, I understand, usually sandy or gravelly or even lacking altogether at times, the muskeg often lying directly upon limestone rock.

About twenty-five miles north of Hudson Bay junction are situated the Pasquia hills, a morainic deposit similar to the Porcupine mountain. If it is considered advisable to make another forest reserve in Northern Saskatchewan, the Pasquia hills would be a suitable area.

The muskeg country extends as far south as Birch river, where a change towards good agricultural land begins to take place. From what I have learned during the

past season, I should say that the area north of the line from Peesane to Birch river and east from Birch river to Lake Winnipeg should all be classed as absolute forest land.

OPINIONS REGARDING NEW RESERVE.

Throughout the season no effort was made to conceal the object of the work, and we tried on all occasions to find what people thought of the installation of another forest reserve.

Almost all the settlers questioned were of the opinion that the reserve would be most valuable in years to come. For the most part the rich country to the south is rather lacking in timber for fuel and building purposes. Every year large tracts of the small poplar are burned over, and the people know that before long they will have urgent need of fuel. The existence of the area of bad land examined during the past season was known to most of those questioned and they agreed that it would be well to have the timber on it set aside for the good of the community.

The settlers who objected to the reserve were those situated a short distance from the useless country, who hoped to see the land further back settled up in order that their own quarters might be of more value.

The lumbermen consulted were all in favour of the reserve, because they believe that if settlers are allowed to enter this country the temptation to use fire for clearing land would prove too great for the most of them with the result that the safety of the whole country would be endangered. The lumbermen also knew that there are large areas of good spruce reproduction, which, if protected, will soon be of value and they are anxious to see fire kept out of the whole area.

Respectfully submitted,

W. L. SCANDRETT,
Forest Assistant.

APPENDIX No. 8.

REPORT OF RECONNAISSANCE IN CENTRAL SASKATCHEWAN.

Forestry Branch,
Ottawa, March 1, 1913.

R. H. Campbell, Esq.,
Director of Forestry,
Ottawa, Ont.

Sir,—I beg to submit a report of reconnaissance work done during the past summer.. The district examined stretches east from the Big River branch of the Canadian Northern Railway to the third Dominion meridian, (Astronomical meridian, 106 degrees) and north from the line between townships 50 and 51 to that between townships 56 and 57. The object of the survey was to determine whether any of the land was so little adapted for agricultural use that it ought to be placed in a forest reserve.

DRAINAGE AND TOPOGRAPHY.

The country is generally rolling and is dotted with lakes and sloughs. It forms the divide between two great river-systems, the Churchill on the north and the Sas-

katchewan on the south. This watershed is drained to the north by Big River and Red Deer rivers and to the south by Sturgeon river and Little Red river. The two last-named streams are used for log-driving by the Prince Albert Lumber Company.

SOIL DESCRIPTION.

A description of the soil of this area is rather difficult on account of its wide variability. No out-croppings of rock are found. In a general way the soil west of the Sturgeon river is a rich clay loam with a clay subsoil. Patches of sandy land are found here, but they are small and few in number. One sandy area lies just south of the town of Big River, one is at Dumble and another just to the north of Karl's Lake. Land of this general type is being successfully farmed in Township 51, ranges 4 and 5.

East of the Sturgeon river the sandy patches form a larger percentage of the land, and in many places the soil is stony. Although there are considerable areas of absolute forest soil in this district, it is very difficult to put these into a reserve on account of their purely local character, especially since the land is unsurveyed.

CLIMATE.

It is obvious from the geographical situations of the district that both mean monthly temperature and precipitation will be low. Meteorological records made at Prince Albert bear this out. The following are the averages of the monthly temperatures and the monthly precipitations for a period of twenty years (1888 to 1907 inclusive):—

—	Precipitation.	Temperature.
January	0.83 in.	3.3 deg. F.
February	0.73 "	0.4 "
March	1.03 "	12.3 "
April	0.82 "	36.6 "
May	1.54 "	49.1 "
June	2.63 "	57.6 "
July	2.42 "	62.1 "
August	2.53 "	59.4 "
September	1.44 "	49.1 "
October	0.86 "	38.8 "
November	0.97 "	18.3 "
December	0.73 "	5.5 "

Total yearly precipitation, 16·53 inches.

Average yearly temperature, 32·1 degrees F.

Average temperature for the four growing months, 57 degrees F.

Total precipitation for the four growing months, 9·12 inches.

The rather scanty precipitation is offset by the good depth of soil and by the presence of countless reservoirs in the form of lakes and sloughs. The annual range of temperature is very great. I was informed that last winter the thermometer stood for a couple of weeks at 58 degrees below zero F. I recall three days during the summer when the temperature was well over ninety degrees Fahrenheit.

FOREST TYPES.

The forest of the Prince Albert district may be described as the spruce-aspen type. These two species are found in both mixed and pure stands. Fire seems to be a more important factor in determining the species than the soil conditions of the site. After

a burn, poplar seeds-in quickly and establishes itself to the exclusion of spruce. As the poplar approaches maturity and begins to thin out, spruce seedlings appear if seed trees have been left. The original forest was probably spruce, and if protected from fire it would ultimately be re-established.

On dry sandy ridges jackpine predominates, although in many cases white spruce was found growing side by side with it in very coarse sand. The roots must get their moisture by seepage from the numerous small lakes.

On moist but fairly well drained sites balsam poplar takes the place of aspen, but this type is not extensive enough to be important.

White birch is intermixed with spruce and poplar on well-drained slopes. A type often met with in the region just east of the Sturgeon is what might be called poplar reverting to prairie. This type is found on rather dry soils. The stand is an open one of straggling poplar and scattered jack pine. The grass cover is well established.

Muskegs are very numerous everywhere in the district. They are of two types, high muskegs and low muskegs. The former are fairly dry and support a dense growth of black spruce and scattered tamaracks. The latter are covered with a mixture of sphagnum moss and grasses and are usually folded. Many transitional forms between these two types are found.

Sloughs are most abundant in the district west of the Sturgeon river, where they rtsetch in chains for long distances. Sloughs of the drier type are very valuable as hay meadows. Just as there are intermediate types between high and low muskegs, so there are transitions between sloughs and muskegs.

Summary of types.—

1. Spruce-aspen, plain type.
2. Jack-pine, ridge type.
3. Poplar reverting to prairie.
4. Muskeg.
5. Sloughs.

Species.—

Picea canadensis (White spruce).
Picea mariana (Black spruce).
Pinus Banksiana (Jack pine).
Larix lariciana (Tamarack).
Populus tremuloides (Aspen).
Populus balsamifera (Balsam poplar).
Betula alba var. *papyrifera* (Canoe or paper birch).

FIRES AND REPRODUCTION.

A great deal of the country has been fire-swept at various times. Fires have occurred in merchantable timber within the past five years in the following places:—

At the town of Big River in the southwest corner of township 56, range 7, west of the 3rd Dominion meridian, about 1½ square miles of spruce and jack pine.

At Dumble Siding in township 54, range 7, west of the 3rd Dominion meridian, about six square miles of spruce and jack pine.

In township 54, ranges 5 and 6, about five square miles of spruce. In township 53, ranges 2 and 3, about four square miles of spruce and jackpine.

Large areas of young poplar with scattered charred stubs give evidence of great fires at more remote dates. The only fire that came to my notice in the district during the summer was in the valley of the Little Red river about a mile north of Angling Lake camp. Only a small area of young jack pine was burned.

Poplar reproduction is excellent everywhere, except in the dry belt mentioned before just east of the Sturgeon river and above township 52. Here the land is reverting to prairie.

Spruce seeds under a cover of poplar, hence it is not found for some time after burns.

Jack-pine reproduction is generally satisfactory. On account of its dry site this species needs special protection. Every stand of jack pine examined during the summer showed evidences of fire.

LUMBERING OPERATIONS.

Two large lumber companies are operating in the district examined, the Prince Albert Lumber Company and the Big River Lumber Company. Spruce is the only timber cut. The limits of the Big River Lumber Company are nearly all located around Crooked lake. The mill is at Big river. Timber is driven down the streams to Crooked lake and is rafted to the mill. Large quantities of logs are brought in by rail from near Polwarth.

The limits of the Prince Albert Lumber Company are all within the district I examined. They have, in all, sixteen camps, of which fourteen were running last winter. Last season's cut was particularly high on account of fires in the previous summer. Two thousand two hundred men were employed in the woods and the cut amounted to 50,000,000 feet. The timber is driven down two meandering streams, the Sturgeon and the Little Red river. The company's mill is located at Prince Albert, on the Saskatchewan river, just opposite the mouth of the Little Red. The Sturgeon empties into the Saskatchewan above Prince Albert, and the logs are rafted down to the mill. Last summer a logging railway was built from Polwarth to Camp 'D', so that now a large portion of the cut will be transported by rail to Prince Albert, a distance of about fifty-eight miles.

The grade of lumber cut is No. 2 common without any clear or uppers. It is marketed all over the prairie district.

FISH AND GAME.

Whitefish of splendid quality are caught in the large northern lakes. In the Sturgeon and Little Red rivers no trout are found, but pike, pickerel and suckers are plentiful. Ducks and grouse are found everywhere in large numbers, and moose and deer are plentiful, as many as five moose having been seen in a single evening.

DETAILED DESCRIPTION.

Between the Canadian Northern railway and Ladder lake is a range of hills covered with spruce and jack pine of merchantable size. The western slope of this range was burned two years ago. These hills slope out into rolling land in the neighbourhood of Bodmin. East of this range the land is gently rolling and is for the most part covered with young poplar. Occasional small patches of jack pine occur.

At Dumble another sandy belt is found, covered with jack pine and a little spruce on the borders. This is a projection of a larger sandy region west of the Canadian Northern railway. The timber here was recently burned and is now being cut for cordwood. It is mostly of pole size.

South and east of this, the country is of the sloughy poplar type. A great chain of lakes and sloughs begins just south of Ladder lake, where there are great hay meadows, and runs south approaching the railroad below Dumble. It extends to the bottom of township 52. Many fine hay sloughs are found in this strip.

At Polwarth there is a small patch of logged-over spruce. Starting northeast over the new Prince Albert Lumber Company's logging road, one passes through about three miles of young burned poplar. This type continues south and takes in nearly all of township 51, range 5, which is well settled. Continuing along the

logging road, one comes to the spruce block which originally included, in a general way, townships 52 and 53, ranges 4 and 5. Township 52, range 4, has been pretty well logged over and burned. The best timber is found on township 52, range 5.

The part of township 52, range 3, southwest of the Sturgeon is all open rolling land reverting to prairie. Much of it is covered with young burned poplar, under which a luxuriant growth of pea-vine is found. I talked with several men during the summer who have just located homesteads in the southern part of this township.

The part of township 52, range 3, northeast of the river is very rolling and considerably broken by muskegs and sloughs running parallel to the river.

Township 51, range 3, was once a timber berth but it has been denuded except for a small area at the north end of Big Sucker lake. The southwest part of the township already has a number of homesteads.

East of the Sturgeon, beginning at the base of township 53, and running north parallel to the river, is a belt of open park-like country. This is sparsely covered with poplar and occasional jack pine trees. The grass cover is well established. Here and there patches of pure jack pine occur. In the open poplar type the soil is a peculiar dark dry loam resembling that of the southern prairies, but with coarse sand particles mixed through it.

Continuing east on the 'tote-road' one arrives at another patch of spruce which takes in the central part of township 53, range 3. This is now being logged from camps 5 and 6. The land is clay loam but is hilly. Camp 4 is in the middle of a patch of rolling, sandy land covered with burned jack pine and spruce.

Township 53, range 2, is nearly all spruce but it has been pretty much logged over except in the northeast corner around camp 2. The southeast corner is poplar land. The north half of the township is hilly and in places stony. This is most noticeable around camp 1. Township 52, range 2, is nearly all poplar and is being homesteaded in the south. The eastern part was spruce-covered, but it was logged several years ago.

Township 53, range 1, is quite hilly. The only spruce on it is in the northwest corner. The rest of the township is jack pine or grassy river-bottom land.

The valley of the Little Red river is sandy throughout, but back from the stream at a distance of about half a mile on each side the soil becomes heavier.

The west half of township 54, range 1, is hilly. It has fair soil and is spruce-covered, as is also most of township 54, range 2. The timber is at present being logged.

Township 55, range 2, and a strip on the west side of township 55, range 1, has good spruce partly logged. The south half of township 55, range 3, and the north half of township 54, range 3, were of the same spruce type, but were burned several years ago.

Township 56, ranges 1, 2, 3, 4, and township 55, ranges 3 and 4, contain no timber of importance. The growth is mostly small poplar with ridges of jack pine.

To sum up, the district lying between the Sturgeon river and the third Dominion meridian, and north of a line between townships 52 and 53 contains a large percentage of non-agricultural land. Much of it is heavily timbered. It forms the divide between two large river-systems, so that its relation to stream-flow is important. For these reasons it ought to be maintained as a forest reserve. Certain areas may, however, have to be thrown open for settlement later, when a more detailed examination of the land has been made and when agriculture is sufficiently intensive to utilize inferior land.

PROPOSED RESERVE OUTLINED.

A careful study of forest and soil conditions has led to the suggestion of the following boundaries for the reserve:—

On the north, as a provisional boundary, the line between townships 56 and 57;

On the east, as a provisional boundary, the third meridian from the line between townships 52 and 53 to that between 56 and 57;

On the west, the Sturgeon river, from the line between townships 52 and 53 to the line between townships 55 and 56, thence east to the line between ranges 4 and 5 and north on this range to the base line between townships 56 and 57:

On the south, the base line between townships 52 and 53 from the Sturgeon river to section 3, township 53, range 3, thence north one mile along the west side of section 3, thence east four miles along the north side of sections 3, 2, and 1, in township 53, range 3, and section 6, township 53, range 2; thence north two miles along the west side of sections 8 and 17, thence east seven miles along the north side of sections 17, 16, 15, 14, 13, township 53, range 2, and sections 18 and 17, township 53, range 1, thence south 3 miles along the west side of sections 16, 9 and 4, to the base line between townships 52 and 53, thence east four miles on this base line to the third meridian.

MANAGEMENT.

Protection from fire must be the first step in the management of this reserve. Sites for lookout stations are numerous, and the building and equipping of these would greatly facilitate the work. Since the Canadian Northern railway now patrols its own lines, rangers will be needed only along the line of the lumber camps from Polwarth to Shoal Creek Landing and up the Montreal Lake trail. From Polwarth to Shoal Creek there are about sixty miles of trail, within the reserve and outside of it, that ought to be patrolled. These trails, however, form such a network that a satisfactory ranging system will be difficult to work out. From Shoal Creek Landing to Montreal lake there are about forty-five miles of trail to be patrolled.

All the merchantable timber in the proposed reserve is already in the hands of lumber companies. Much of the remaining timber would be valuable for cordwood if the transportation facilities were better, but at the present time the marketing of it would not be profitable. It would seem, then, that for a considerable time the work of a forester on this reserve will be confined to protection from fire

Respectfully submitted,

C. H. MORSE,
Forest Assistant.

APPENDIX No. 9.

REPORT OF RECONNOISSANCE NORTH AND EAST OF LAC LA BICHE.

FORESTRY BRANCH,
OTTAWA, February 7, 1913.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa, Ont.

SIR,—I have the honour to submit herewith a report of the reconnaissance survey of the region north and east of Lac la Biche, in the northern part of the province of Alberta, made under your direction during the summer of 1913.

Developments at Lac la Biche and the call from McMurray brought to the attention of the Forestry Branch the timber possibilities in that direction and during last winter it was planned to send a reconnaissance party north of the lake.

With the idea of setting aside forest reserves are associated (*a*) the application of a more efficient fire-protection system and (*b*) the prevention of poverty which arises from homesteading on land which is unfit for crop production. To the prospective homesteader or superficial observer the latter has little weight, but experience has taught that in districts where land is likely to be impoverished in a few years, total prohibition of settlement and the poverty consequent thereon is in the best interests of the applicant.

Regarding the agricultural possibilities, few reports of the country in question have been made previous to this. These vary, depending upon whether the explorer forms his opinion while following a dog-train when the muskeg low-ridge type appears as prairies with poplar bluffs or whether he has had to portage his pack-train over the same prairies in mid-summer.

GENERAL PROCEEDING.

Instructions to examine the district north and east of Lac la Biche, outfitting as much as possible in that vicinity, were received on the fourteenth of May. With very little information regarding trails, &c., I proceeded to Edmonton arriving there on May 18.

Upon the best advice which I could obtain (thanks to Mr. Jas. Spencer, Lac la Biche) my plans were altered. Horses, if for sale at all at the Lake, were held at a premium and the supply of provisions at the country store was not substantial. Thus I was forced to outfit entirely from Edmonton.

The bad state of the roads from Athabaska Landing to Lac la Biche made it imperative that I should freight via Lamont.

On May 28th Geo. Tunstell, student assistant, reported to me. On the following morning we started having in charge the cook, packer and seven horses, toward Heart Lake, where we were to begin work.

It required six days to freight the provisions from Lamont to Heart lake, a distance of about 180 miles. On June 7th we commenced work with the packer and guide. I hurriedly covered the main trails toward Sand River and became acquainted with the general lay of the country. In the meantime Tunstell and the cook took notes on the surveyed townships south of Heart Lake.

The first two months were spent examining the country north and east of Heart Lake. By August we had reached the McMurray trail west of Owl River. For another month our main camp was located on this trail, while the necessary side-trips east and west, and as far north as the Twentieth Base Line, finished the time-limited northern examination. Turning south we worked on either side of the McMurray trail until we arrived at Big Bay. The inaccessibility of the country west of Lac la Biche made it advisable to leave the pack-train in care of Mr. Jas. Spencer and hire his row-boat. By this means we were able to make a hurried trip down the la Biche river until we were stopped by rapids.

On September 15th we arrived again at the east end of the lake. A week's work toward Trout lake finished a short season's work of four months which was much cut up by rain. Hitching two of the pack ponies to a wagon, we loaded our survey outfit and started for Athbaska Landing. On arriving the team was sent back to where, in care of George Spencer, the pack-train was to spend the winter.

THE REGION.

The region to be described lies about the inter-section of latitude 55 degrees north and longitude 112 degrees west. The examined district, of 1,650 miles in extent, includes a portion of the height of land which divides the drainages of the Athabaska

and Beaver rivers. On this height of land one is impressed with the number of loamy sand and sand ridges, which are covered with poplar and jack pine. The undrained heights of land give rise to large areas of muskeg.

GENERAL CONDITIONS.

Topography.—The greatest part of the trail examined drains into the Athabaska river via Lac la Biche. The eastern ranges drain into the Beaver via Sand river, while the northern townships drain northward into the Pembina river. Lac la Biche covers an area equal to about three townships. From tip to tip the length measures about fifteen miles and the width varies up to nine miles. Its main water-supply comes from Owl river. This stream finds its source in the large muskegs of the north. It is very winding and hence has a slow current, except near its source.

Sand river, so called because of the predominance of sand in its course, is comparatively free from rapids. For the most part it is shallow and crooked. It is mainly characterized by the omnipresence of jackpine on the low ridges which extend on either side.

Heart lake covers about one and one-half townships. Toward the northeast it is dotted with small islands. Its chief importance rests in the fact that a tribe of Indians have camped on its shores for about twenty-five years.

In general, owing to the apparently slow change of elevation, numerous small lakes are found. These, as well as all streams, have a predominance of sand beaches and banks which are indicative of the subsoil.

Soil.—The soil varies from pure humus to pure sand and glacial drift. One is impressed by the lack of the heavier soils. The subsoil in most parts is sand, at least on the ridges.

Soils in relation to agriculture may be classified as follows:—

(*a*) Absolute forest soils.
(*b*) Temporary agricultural soils.
(*c*) Alluvial soils (agricultural).
(*d*) Probable agricultural soils.

The first include the sand soils. They are characterized by having a forest growth of jackpine, a lack of vegetable growth and almost total absence of humus content. The second require special consideration. These soils have become strengthened by the protection of humus given by the deciduous forest growth. The moister portions of these loamy sand areas cannot be said to be non-agricultural, but may be more correctly termed temporary agricultural soils, that is, on account of their shallowness and lightness they would be deprived of their nourishment by a few years of crop production. On these soils are found the heaviest stands of poplar and birch. Where sufficient moisture exists, young spruce will undoubtedly establish itself if unmolested by fire and man.

The alluvial, sedimentary and overflow soils are mostly agricultural, but exist in such small areas as to be negligible except in isolated places. Hay meadows are fairly indicative of these soils.

In the last section of the classification may be included the undrained areas. The problem of drainage of muskegs is at present being widely discussed. Owing to the diversity of conditions which influence the practicability of such a project, we are safe in placing all muskegs in the same group. In my opinion developments in the vicinity of the examined district will not have sufficient force to exclude them from the proposed reserve.

Climate.—Conclusive statements of any district cannot be justly made from one summer's observations, hence only generalities may be discussed here.

The climate of this district varies in no essential from that of Edmonton, though the average temperature for the period from May 15th to September 15th is undoubtededly farther below the optimum for farm-crop production. Vegetables have been grown in small patches around Heart lake but frosts occur frequently in August and September which often cause partial or total loss of the crop.

The general concensus of opinion indicated that the past summer was comparatively dry, so that it may be safely assumed that the precipitation and humidity are ample for agricultural crops and forest trees suited to the climate.

On the whole the climate is characterized by long winters, late frosts in spring and early fall frosts, and considerable variation of heat and cold during August and September. As the best soils are found in the low situations, which are most susceptible to the adverse conditions, it may be concluded that the district cannot claim all the climatic influences which are present in the settled districts to the south.

In connection with the climatic influences it may be noted that the flies are extremely bad, especially in June and July. In the wooded areas the moose flies, commonly called 'bull-dogs,' were sufficiently severe to kill one pack-horse and render the others unfit for work. During the dry season the bull-dogs, as well as the mosquitos and black and sand flies, make it very uncomfortable for both man and beast.

FOREST DESCRIPTION.

The divisions of the forested areas into descriptive types may be designated as follows:—

(1) Muskeg low-ridge type.
(2) Poplar loamy-sand-ridge type.
(3) Pine sand-ridge type.
(4) Muskeg.
(5) Poplar-birch-spruce lake-slope type.
(6) Spruce-slope type.

Muskeg Low-Ridge Type.—This type, comprising approximately 4 per cent of the total area occurred in largest proportion on the undrained height-of-land areas, especially between the drainage of Sand river and the Athabaska. Large areas are also found northwest of Lac la Biche. On this type the agricultural and timber possibilities are particularly discouraging, partly on account of their remoteness and partly because the areas which are not zerophytically dry are small and sandy. These ridges are mostly covered with aspen and jack pine of small size.

Poplar Loamy-sand-ridge Type.—The trail-followers may claim this type to be in largest proportion, because the summer trails take advantage of the higher situations. In fact the type is approximately 30 per cent. It is mainly characterized, topographically, by ranges of hills separated by strips of muskeg, the latter occupying not more than 25 per cent of the type. A predominance of this type is found between Lac la Biche and Little Heart lake, and north along the westerly part of the height of land to the nineteenth base line.

Pine Sand-ridge Type.—This type requires little description, as the presence of jackpine on light sandy ridges is proverbial. It occupies about 20 per cent of the total area, and is found mainly along Sand river, Owl river and the height-of-land betweeen the Owl and Pembina rivers. Being more susceptible to fires, it does not at present exist in large sizes, though along Sand river it may be found in small areas with a diameter up to 15 inches at breast-height.

Muskeg.—This type is differentiated from the first by the absence of the low ridges. The total aggregate of small blocks, amounting to about 5 per cent, is found in increasing quantity toward the twentieth base line.

Poplar-birch-spruce Lake-slope Type.—The introduction of birch (*Betula alba* var. *papyrifera*) and white spruce (*Picea canadensis*) into the poplar type occurs on the moister soils, principally around lakes. This new type, which has been designated by a rather cumbersome, though descriptive, name, forms about 4 per cent of the area. The soil of this type approaches sandy loam, probably because the humification is more perfect with the improved factors of site. The tolerant spruce promises to play an important role in the development of the climax forest.

Spruce-slope Type.—The small percentage of this type, probably less than one per cent, is due in part to repeated fires. Indications show that large areas were once covered with heavy spruce, but after the fire poplar reproduced on the burned soil and the promise of another spruce stand is found only on the moisture soils. A pure spruce stand of about five square miles was located in the northern part of township 68, range 11, west of the 4th meridian, and the southern part of township 69, range 11, west of the 4th meridian. This small stand loses much of its importance, on account of its remote location, at least it is not easily accessible to a practical water-route.

The maximum stand is about 15,000 feet, board measure, per acre, including only white spruce. An average stand would not exceed 5,000 feet board measure per acre. This spruce is over-mature and awaits development by railway.

INDIAN INHABITANTS.

For the last twenty-five years a tribe of Indians (Chipewyans) have camped around Heart lake. Their present state seems to show little advance on their early conditions. A few years ago one could have seen indications of advancement by the number of cattle in that vicinity but the authorities gave inducements for them to go to Cold Lake Reserve, and the more thrifty Indians took advantage of this. The result is that there are about a dozen families with a total census of about sixty, who are of a shiftless and indifferent nature. This is clearly indicated by their lack of industry. Their existence depends almost solely upon the hunt. They shoot and fish at all seasons of the year and pay no attention to the sex of their prey. Attempts have been made to educate the children, but the failure is mainly due to the wild state in which they are living.

GAME AND FISH.

Moose, deer and caribou have been driven into the remote parts by the Indians, but are still plentiful enough to restock the country if protected. The fur-bearing animals have also become scarce on account of the demand for furs. Rabbits are plentiful and very destructive to the spruce and pine seedlings in many localities. Partridge are very scarce. The scarcity is in part due to the Indian who has no scruples against shooting a hen from her nest.

Whitefish and jackfish are plentiful in most lakes and streams. The whitefish are easily caught in nets and provide a portion of the Indians' daily food.

FIRES.

Recent fires have been confined mostly to the jack pine sand-ridge and the muskeg low-ridge types. Reproduction shows that during the last three decades a large proportion of these types have been covered by fire. The quick-seeding jack pine and aspen have taken possession of the burned areas.

DISTRICT NOTES.

The main district is bounded on the east and north by Sand river and the nineteenth base line, and on the west and south by the township in range 14, Lac la Biche

and township tier 66. It offers a great diversity of types, with a large amount of pulpwood, and but one pure stand of merchantable spruce of importance, which has been described previously. The development of this pulpwood and timber will depend upon the extension of a railway in that direction. Sand river and Owl river are both drivable streams, but cannot carry timber into civilization. Closed stands of merchantable jack pine are worthy of note in townships 69 and 70, range 8, west of the 4th meridian.

TRAVERSE OF THE MCMURRAY TRAIL BETWEEN THE 19TH AND 20TH BASE LINES.

The examination north of the nineteenth base line showed a large percentage of jack pine in townships 74 and 75, ranges 11 and 12, west of the 4th meridian. Jack pine in this district exists mostly in open stands and hence is less valuable. Township 76, ranges 11 and 12, west of the 4th meridian, are mostly muskeg. In this muskeg area the Pembina finds its source. A means of development would also put a different aspect on the value of poplar and jack pine in this district.

LA BICHE RIVER TRAVERSE.

Poplar predominates on a strip of varying widths on each side of the river. Behind the river-banks, and often extending to the water's edge, the muskeg and muskeg low-ridge types become conspicuous.

Fifteen miles of river from Lac la Biche is free from rapids but the height of the banks and the number of rapids increase toward the Athabaska river. Near the lake numerous hay meadows are at present cut by half-breeds.

GENERAL NOTES.

In so far as determining a boundary betweeen agricultural and non-agricultural land is concerned, very little was accomplished. In examining east, north and west of Heart lake no areas of agricultural land of sufficient size and importance to justify their exclusion from the proposed reserve were found.

With the exception of a few sections east of Lac la Biche the line denoting the limit of examination may be extended in any direction without intrusion on agricultural soil.

SILVICULTURAL NOTES.

It may safely be said that the climax forest on the best sites will be white spruce, for where there is a stand of poplar or poplar and birch association on a moist soil, there is found a strong reproduction of spruce. The tolerance of spruce if unmolested by fire will guarantee its establishment.

Jack pine, being susceptible to fires and a ready reproducer, seldom enters into an association with the other species, but is mostly found in even-aged stands.

FIRE PROTECTION.

The Indians at Heart lake, the half-breeds on the north shore of Lac laBiche and the travellers of the McMurray or Heart Lake trails deserve special attention. An influential man who speaks the Cree language should patrol the Heart lake trail and keep in touch with the Indians. He should also patrol the trail north of Lac laBiche as far as Owl river, warning the half-breeds camping there.

Travellers going north should be noted and warned. This for the present is sufficient patrol until development to the north demands a more efficient fire-ranging system.

RECOMMENDATIONS.

The Indians at Heart lake have made a request for a reserve there, but in view of their small numbers and the character of the country the granting of such a request hardly seems justifiable. Inducements should be made to them to attract them to settle with their kinsmen at Cold lake. Because of the dependence of their livelihood on the hunt, game laws cannot be enforced. They are also responsible for occasional fires. During the past season two were started by their negligence.

The utilization of the pulpwood should be encouraged, thus improving the possibilities of a spruce forest by natural regeneration. When the development of forestry in Canada demands regeneration by artificial means, the silviculturist will find a large field for operation, especially between Lac laBiche and Heart lake.

The framing of an extensive management and fire-protection system requires more study than I have been able to give in the short summer, but such will gradually grow as developments in that direction demand.

Respectfully submitted,

S. H. CLARK,
Forest Assistant.

APPENDIX No. 10.

REPORTS ON WOOD BISON.

FORESTRY BRANCH,
FORT SMITH, ALTA., May 31, 1912.

R. H. CAMPBELL, Esq.,
Director of Forestry,
Ottawa.

SIR,—I beg to submit the following report of work done by myself since last writing in March.

When orders came for P. McCallum to proceed to the reindeer camp near Chipewyan, it left me crippled as far as tripping was concerned. He took all our tripping outfit, as well as sled and dogs. I was somewhat disappointed, as the joint patrol with the R. N. W. M. P. was to take place in March.

However, I managed to scrape together an outfit, hiring a man and his team. The winter was almost over, but the most important part of it was to come, as I had been led to believe. The buffalo calve some time near the end of March or beginning of April, and we wanted to be in the country at that time.

I made a flying trip to Bear Creek to pick up traps and necessary articles of camping life, and when I reached Fort Smith again Inspector Fields told me that he was not going to send out a patrol. He had heard that the Little Buffalo river, which we were to cross on our trip, was completely flooded. I later discovered that the trail was perfectly sound and was so for a month after that.

I started out with the man and dog-team, following the trail we had taken in January, the one running southwest from Fort Smith and turning due west after crossing Salt Mountain.

My object was to visit a place called the 'Little Fishery,' known to many Indians up here, and which is located on an upper tributary of the Little Buffalo river. We were short of fish, and Mr. Bell thought it a good idea to ascertain the location of

the place and any other particulars that might be useful. After following some very misleading and altogether foolish directions received from, as we thought, reliable Indian information, we located the place more by the sense of smell than anything else.

This 'Little Fishery' is very interesting and important, in that it is the only place near Fort Smith where fish can be obtained during the winter with which to feed the dogs. The shortage of fish at the Fort and elsewhere seems to be chronic, no matter how big the run is in the fall. This is, of course, due only to carelessness and laziness. But the Indians know that if they run short towards the end of winter they can easily get all they want at this place.

It is at the confluence of a small shallow stream and the upper part of the Little Buffalo river, some two and a half days' travel in the winter, from Fort Smith. It is marked on the map thus ⊙. The fish are suckers, and are there during February and March in such quantities that they fill the stream from bank to bank. They keep the river open for three or four hundred yards, although two or three feet of ice cover the river below this point. They are rather small, the largest of them weighing only one third of a pound and the smallest being only minnows. However, what they lack in size is made up in quantity. What their object is in congregating there in such numbers, I have not been able to ascertain, but it is clearly not to spawn, as that comes later in the spring when the ice leaves the shallow streams and rivers.

The method of catching them is simple and primitive. They are simply scooped out with bags tied on the end of poles, and a pile is made on the snow on the bank. Here they freeze solid and will stay so until late in April. When we arrived they had nearly all gone, but we managed to get six or seven bags full without very much trouble. They must have been there in enormous quantities as huge masses of them were frozen in the ice along the shore, and piles of dead fish could be seen everywhere behind sunken logs, driftwood, and holes in the bank. Of course, this will be of prime importance to us as we can use it as a basis of supply of dog-feed when in that part of the country.

No tracks of any kind were discovered by us on the outward or the inward journey. The snow was very soft and a hard crust formed on it every night, so animals of every kind moved about as little as possible.

I spent considerable time and effort looking for a good situation for a house on Salt Mountain. You know that fresh water is very scarce there and we are fortunate in having located a good-sized fresh-water lake, one of those deep crater lakes you have heard spoken of. This situation is very strategic, I think, as you will see by the map.

My plan which I have talked over with Mr. Bell is this: The house we use as a sub-headquarters or main residence, should not be more than a days' journey in winter-time from the Fort, as Mr. Bell can then keep pretty well in touch with us. It should also be centrally located, so that we would never be farther from one field of operations than from another. We want to get over as much ground as possible in the winter, and in order to do this, we must use, as much as we can, any existing trappers' (Indians') trails which have been broken and are in use.

Breaking trail is a very hard task, and two men could never hope to break trail all winter (that is, new trail), and go any distance or cover any large territory. Therefore, my plan is to make a cross trail of our own, bisecting all the other trails which radiate from the settlements on Slave river and which one and all run westward. This trail will run north from the proposed shack as far as our Bear creek hut, or, maybe, farther; and south, intersecting all the trails from Smith landing as far as Peace river, or, in any case, as far as Pere Muster's shack. I don't quite know the location of this shack. It is one built bp the man whom the R. N. W. M. P. had hired before we came in here, and who, I hear, is a splendid trapper and hunter. It is centrally located on the Southern Buffalo range, and would make a splendid southern terminal for our trails.

Thus you see, we would cross the trail of everybody who went into or crossed the buffalo country, and as these trails are kept open more or less all winter, we could use any or all of them in travelling over the country.

I am very sorry and disappointed not to be able to furnish you with an estimate of the number of buffalo in each range. My information, both from observation and hearsay, is too vague and uncertain to be of any practical use. This was caused, of course, mainly by our prolonged stay around Bear creek, under McCallum's advice. However, I know this much, that there are 50 to 100 head scattered over the district just west of the proposed house; 100 to 150 head in the southern, or Peace river, herd; and 50 in the northern, or Resolution, range.

I expect to start out on a trip by myself next week. I have been travelling alone for some time and getting along very well. However, for the last three weeks I have been looking after the summer dry-fishery at Salt river. Here, with the aid of two women, I put up 1,600 fish for the dogs during the summer.

I expect McCallum will be busy with the reindeer for some time yet, so I will do as much travelling as possible by myself, and leave the erection of the house until his return, or at least until Mr. Bell returns from McMurray, where he has gone to meet the treaty party.

I have established a camp with a tent and supplies out on the mountain near the site of the house, and as soon as I can get help the house will be built. Of course there is no immediate demand for a house. As long as it is built before the winter sets in we can get along all right.

Respectfully submitted,

GEO. A. MULLOY.

II.

Forestry Branch,
Fort Smith, Alta., August 20, 1912.

R. H. Campbell, Esq.,
Director of Forestry,
Ottawa.

Sir,—I beg to submit the following report of work done by myself and P. McCallum since last writing in June.

During the latter part of June, as Mr. McCallum was still away in connection with the reindeer, and as Mr. Bell had gone up the river to meet the treaty party, I decided to make a horse trip by myself.

I wished to see the country north of the proposed site of our house on Salt Mountain, to determine the feasibility of running a winter trail in a northwesterly direction, connecting several of the Indians' winter trails, and also to determine whether this was a country inhabited by the buffalo.

Although the flies were very bad, I made good progress for a day and a half north of my camp. Here, however, I was stopped by a ground fire which was burning all the grass and small bushes in every direction. It had evidently come from the north-west, and, when I discovered it, had covered an enormous area. Of course, it was impossible for me to proceed, because all the feed for the horse had been burned and the fire was rapidly approaching my camp, some fifteen miles to the south.

I tried to put out the fire. I fought it for several days, beating it out with a brush, but as I could only put it out in one direction at once, it kept burning behind me and my efforts were of little or no use. At last I decided to return and burn around my camp. This was slow work, as I did not want the fire to get out of hand. However,

my difficulties were solved at last by a huge downpour of rain which put out the fire in every direction.

The country I travelled through is of much the same character as that around my camp on Salt Mountain, very hilly, mountanous in fact, the higher hills covered with fine jackpine, and the valleys filled with a dense growth of good poplar.

I had been warned that water was scarce, that is, good water, as all the lakes were salt; but this information is far from correct, as each depression has its little lake, and every one I struck was fresh.

Old buffalo trails are very plentiful, but no fresh signs were seen. They evidently, at one time, were very plentiful here, and, I think, would still inhabit this part of the country if it were not for the fact that this is a great country for moose and hunted over by the Indians from both Fort Smith and Salt River settlement.

On the 1st of July I returned to Fort Smith and found P. McCallum waiting there for me. We immediately made preparations and started out to Salt Mountain to build the house.

The situation of this house I described to you in my last report. It is situated on a small lake two or three miles west of the eastern face of Salt mountain. Altogether it is twenty-five or twenty-six miles from Fort Smith and on one of the principal winter trails used by the Fort Smith Indians. From here it is our intention to make a trail both north and south, connecting all trails entering or crossing the buffalo country.

Although hampered for lack of tools, we put up a very presentable shack, 10 feet by 11½ feet, inside measurement. We have still some work to do on it which can can be finished in the fall before the snow comes. I have enough supplies out there for two or three months, so no time need be lost in packing on horseback. On Monday, July 15, we arrived at Fort Smith.

Mr. McCallum and Mr. Bell had been talking the situation over in my absence and had come to the conclusion that a stopping place or house at Fort Smith was absolutely necessary. Whenever we come to Fort Smith we have been stopping with the Agency Farm instructor in one of the Northern Trading Company's buildings. This has been taken over for their own use by that Company, and we have no place at all to stay when we come here to report.

An expenditure of $200 was authorized for a building on Salt Mountain, but as we have put up a building of fair dimensions without any expenditure out there, I think that the appropriation should be devoted to this building at Fort Smith. Mr. Bell will advise you in regard to this.

So for the last month we have been putting up a building at Fort Smith. We expected to have finished it long ago, but owing to the scarcity of lumber, shingles, &c., we have been very much delayed. It is nearly completed, or as near as can be until we can obtain some more lumber.

The fishing season is nearly here, and unless we can arrange to have the fishing done by someone else, we will not be able to make a trip until its completion.

In conclusion I would like to say that if the management of this work were placed in the hands of one man, that better results could be obtained.

Respectfully submitted,

GEO. A. MULLOY.

III

Forestry Branch,
Fort Smith, Alta., November 12, 1912.

R. H. Campbell,
Director of Forestry,
Ottawa.

Sir,—I beg to submit the following report of work done by P. McCallum and myself since last writing in August.

As I intimated at the close of my last report the fishing season was approaching; so we moved down the Slave river to our last year's fishing grounds at Bell Rock.

This year we have two trains of dogs to provide for, so we had to catch as many fish as possible during the short time that they were running. The catch this season, however, was not up to standard, the heavy run of fish lasting only three or four days. We stayed down there two weeks, from September 1 to September 14, and managed to put up five hundred or more fish. This amount, supplemented by some rabbits and what small fish we are able to get at the Little Fishery on Little Buffalo river, will keep the dogs in good working condition until the spring.

The main part of this report will be taken up with a detailed account of the long trip which we have just completed, with horses as pack animals. This trip, I will say at the start, was, in my estimation, the most successful and most satisfying to me, personally, of any which I have yet made, not only on account of our success in getting so close to the animals, whose welfare is the main object of our exertions, but also because we were able to spend a protracted period in buffalo country without being forced to return for supplies.

The fall is certainly the best time for travelling in this country. The water which in June hinders travelling to a great extent has been nearly all drained off; the flies which worry the life out of man and beast alike are all dead and the leaves have fallen, allowing one to see through the branches of the trees and get an idea of the country on either side of the line of travel. September and October were ideal months this year.

On Tuesday, September 24, we started for Salt Mountain. It was our intention to spend a few days fixing up the house which we had built there in the summer and then to strike out west from that point. Owing to a late start we were forced to camp at the government farm on Salt river. It snowed heavily at night, the first snow storm of the season, and consequently next day was very bad for travelling. We obtained another pack horse at this point. Crossing Salt river we headed across the Salt Plain for the mountain. We should have reached the shack early in the afternoon, but in making a detour to the Salt springs to get some salt, we found an old trail which we thought might take us up the mountain near the shack and thus avoid some bad crossings on the old trail which skirts the Salt Plain. But it 'petered out' very shortly, and as the day was very cloudy and the country very hilly and wooded we got lost and had to camp. This part of the country (that is, the eastern face of Salt Mountain) is very broken and precipitous in many places, sloughs and boggy places alternating with steep cut-banks and rocky slopes. Of course, it is all well wooded, the higher hills having the good timber, and the lower reaches, scrub spruce and tamarack. Altogether, it is impossible travelling for horses or nearly so, and as this condition holds good for nearly the entire length of the mountain we should have profited from our experience and avoided it in the future. Some of our later experiences will show whether we did or not.

Next day, September 26, after skirting the edge of the mountain, taking our correct course by the sun, which had come up bright and clear, we struck the trail

and arrived at the shack before noon. I would state that by taking an average of the estimates of different people I think this shack is about twenty-five or twenty-six miles from Fort Smith.

Here we stayed until Monday, September 30, working at the house. This house is made almost entirely with the axe, but it is a model of convenience and comfort. The walls had to be all caulked with a tough moss or alga, obtained from the bottom of a pond. Very tiresome work it was too, but the result justifies the trouble expended, as it will stand for six to ten years as good as new. No mud could be obtained nearer than three miles or it would have been used.

Early in the morning of September 30 we packed up and started westward. We took 50 pounds of flour and about 30 pounds of bacon. This, with what game we managed to kill, we expected to see us through until we were forced to return by the snow. This is the trail which goes to Little Fishery and on to Caribou Mountains which we were out on last January and which I described in my report then. The country, of course, slopes gradually to the westward, as this is part of the watershed of the Little Buffalo. Jack pine hills give place to big open poplar and clumps of good spruce. Then, for four or five miles a spruce muskeg and very old spruce brulé intervenes, then Flat Grass lake is encountered. The winter trails run right down the middle of this lake, but the summer trail branches off to the northwest shortly before the lake is reached, following the rolling hills and ridges, covered in places with thick small poplar and dotted here and there with open glades and meadows of thick grass. The lake itself is long and narrow, wider at its more eastern extremity. A thick growth of long rushes lines the shore and the poplar country holds good all around it. Here it was that we saw so many buffalo tracks last winter, crossing the lake, and here it was again that we found much evidence that many buffalo had been feeding in this locality all summer. This country, I think is the limit of Peace river buffalo. Although there are many good crossings on the Little Buffalo river, we found absolutely no trace where any of the animals had crossed and thus entering the country inhabited by the northern bands.

We camped in the poplar country to the north of Flat-grass lake.

Next morning, October 1st, after going two miles or more we came to the crossing on the Little Buffalo river. The river here is not very wide, thirty feet or thereabouts, but it is very deep and the steep banks render it very difficult for horses to cross. It was therefore necessary to look for a better crossing, one of us going up and the other down the river.

The fringe of spruce which lines the river is very good just here. The river is very crooked, but this fringe or bluff of good timber does not follow all its curves. Dense growths of willow and poplar clothe the bank right to the water. This is the home of the beaver. We saw about half a dozen lodges which were occupied, and were everywhere along the bank, and even 100 yards from the water these animals had been at work, felling poplar for feed. One does not realize the enormous labour which they undertake until he sees a whole bluff of good-sized poplar, lying flat on the ground.

The remainder of this day we spent exploring ,and not finding any suitable crossing we decided to strike south following the river-bank.

Wednesday, October 2, was fine and we went south until noon following an old trail which skirted the river-bank. We found three good crossings, where the river was rocky and shallow, but owing to the absence of any sign of a trail and the dense appearance of the country across the river we did not cross until the last one at noon was encountered. The country on the east side of the river is rolling, covered with small poplar and spruce, with a low swampy stretch of spruce near the river.

Crossing the river we circled around to the northwest, following the hills as much as possible until we again came to the winter trail near the Little Fishery on the Buffalo river. This country to the west of the Little Buffalo, or rather enclosed in

the big bends of the river which primarily comes from the northwest, is rolling in character and covered with jack pine, spruce and poplar of good commercial size. The spruce especially is more than a little above the average. To the north and east of the Little Fishery and Old Charlie's shack run ridges of good spruce. Near here we camped for the night.

Thursday, October 3, was also fine and we followed the trail westward for a couple of hours through scrub prairie and small spruce country until we encountered the high jack pine hills. These hills are higher and steeper than any others in this district, and run in a broken line to the northeast. The crest of the hills is fine walking. No fire has yet burned off the thick carpet of needles, and the trees, while big and tall, are not thick enough to impede one's progress or prevent one from seeing where he is going. At a little lake in the midst of the hills we spelled for noon and then reconnoitred without the horses. We found the trail of a big bull buffalo heading southwest and fairly fresh, but as no others were encountered we concluded he was just a stray animal making a circle through the hills and would come back to the higher country to the east and north.

As the high country seemed to hold good to the northwest and west we headed in that direction. Thick small poplar on rolling hills were encountered. Then the travelling became very bad with old brulé on every side. This is very old, and a second growth of small poplar has sprung up, making progress very slow and the result of much arduous labour. From the top of one of the hills we described the course of the Little Buffalo river, which here makes the turn coming from the far northwest. Its course can be clearly picked out, as the dense growth of willows, which edge the bank, have a bright red fringe on top where the new growth has taken place. In this old brule, second-growth poplar country, we camped for the night. Along towards morning a moose visited the horses but cut his call too short for us to get a shot at him.

Friday, October 4 was dull. Keeping in the same direction, west to northwest, we twisted, cut and fought our way through bad going until in a short time, two hours or so, we struck the course of the Little Buffalo. As it was coming from the direction in which we wanted to go, our troubles were over for the time being. The river was now bordered by a wide strip of hay land. Long thick grass, sometimes shoulder-high, followed the bank right along, confined and separated from the big dense brulé to the east by a dense fringe of alders and willows. The walking underfoot was very lumpy and uneven, but as we were avoiding the brulé we were well satisfied. This lasted until the middle of the afternoon. Then the Little Buffalo turned away westward, and we had to strike back into the bad going. The same old brulé, thick poplar country, was met everywhere. Towards night McCallum went ahead alone to reconnoiter. The night became very dark and he got lost, or, as he puts it, the camp got lost. By use of our two rifles and strenuous vocal efforts, he reached camp late at night.

Saturday, October 5, was cloudy. Brulé—thick dense tangle, masses of it. McCallum undertook to get us out of the mess, but owing to his uncertain wanderings the night before was rather mixed up. Our travelling until noon could not be called 'going ahead'; we simply wandered—that was all. At last, shortly after noon, we struck a freshly blazed trail through this tangle. It came from the east and was heading west and north, so we followed it. Two hours' good travelling brought us to a big lake. This lake is almost as big as Moose lake and has some good-sized islands in it. The shores and islands are well covered with good spruce which seems to have escaped the numerous fires which run through here every year.

From the lake the trail headed northwest through small spruce muskeg, coming very shortly to a small muskeg lake. All about this lake a fire has run this season. It was set undoubtedly by moose hunters.

Let me interpolate a short explanation of this large amount of brulé, old and new, in this part of the country. There is an old man up here who has a great reputation as a moose hunter. In fact, this fall, he, or the members of his hunting party, killed from seventeen to twenty moose. Now it is a known fact that moose like brulé. It is rather open for the wind to drive the flies away, and it affords good feeding for them on the willows which everywhere spring up. So it seems to have been, and is still, the custom to let a fire run through a new part every season. I have been, at times up to the present, greatly puzzled to account for the absence of timber on good high ground, capable of supporting a good thick growth of timber. The very old brulé does not show very much, on account of the thick growth of saplings which everywhere covers the ground. But this, then, is the explanation. Furthermore, I have just learned that an old custom existed of setting a fire every time a moose was killed, which, I think, is more or less maintained to this day.

The country all about is becoming very swampy and low. Spruce muskeg predominates. The trail continues in a northwesterly direction, and we travel late at night in endeavour to get a good camp and feed for the horses. We camped at last in a muskeg.

Sunday, October 6, was cloudy. Early in the morning we heard a band of wolves howling, towards the north. From the howls we concluded it was a bitch wolf and some cubs. I baked bannocks while McCallum set out along the trail to see if it went in the right direction, or at least in a northwesterly direction. About noon he came back with the information that it makes a circle and turns back south. So in the afternoon we reconnoitered in the direction in which we had heard the wolves. It was impassable country for horses. There were sloughs and muskegs on all sides, and we ourselves could hardly get through. The whole country here is one big bog, where even a moose wouldn't attempt to go.

Monday, October 7, was cloudy. In the morning we tried another road, again leaving the horses. Following the trail for a mile or so we branched off to the northwest in big poplar and spruce country. The timber was very good, including large quantities of big spruce, but the bluffs were not contiguous, just scattered here and there, the intervening spaces being filled in with dense swamp. After wandering all morning, climbing tall trees and following the big timber as nearly as possible, we stopped and held a council. We decided that, as the country ahead as far as we could see was the same, that is, almost impassable for horses, we had better return on the trail until we came to the higher jackpine hills to the east. This, certainly, is no buffalo country as there was scarcely enough feed for the horses at the camp and none further on. Moreover, a buffalo could not travel at all here. He has to have a firm footing. His legs are comparatively short, and he is not able to wade through quaking bog-holes, like the moose. So, packing up, we returned to nearly the place on the trail where we first struck it, and camped in the brulé. Rain came on, and then frost.

Tuesday, October 8, was cloudy and windy. The big brulé continued east until the middle of the afternoon. Moose hunters had been busy just a few weeks before on this trail. We saw where they had made many kills and much meat had been packed on dogs. We crossed on the range of hills, and next came to where they had made a big cache of meat. Of course as the meat was all dried this cache was big enough to contain eight to ten moose. Jackpine hills were the order of the day. We camped at the cache.

Wednesday, October 9, was fine, with a southwest wind. Following the trail, which runs around the southern extremity of a good-sized lake and then heads northeast, we came to the big jackpine hill country. This is the continuation of the big range of hills which we left on October 3. All day we travelled through jackpine hills with deep valleys, containing grassy sloughs and lakes. Fine big jackpine cover all the hills, but much of the country has been burnt over. We found by experience that,

although in places the trail is very faint, it is better to spend some time in working it out than to make a road for ourselves. Our idea was to follow the ridges around to the north and east until we came to the big poplar country inhabited by the buffalo. Snow at night.

Thursday, October 10, was fine, with a southwest wind. Trail very faint. Got close to P. Squirrel's winter trail. Jackpine ridge country and old brulé. Old brulé and small poplar country later in the day. We came north and then east, northeast generally till three o'clock. We hit an old winter trail and struck northwest, making trail for ourselves. Very bad travelling. We crossed a small creek coming from the southwest (we had to make three crossings for the horses owing to its winding nature). Then we headed for the jackpine hills to the northwest, where we camped at an old moose hunter's camp. Small, thick jackpine interspersed with small poplar predominated.

Friday, October 11, was fine and windy. We followed small jack pine ridge north for a short piece, but it ran out, and we struck for big timber to the north and west. High hills were visible, and we had bad going, through old brulé. We crossed one small creek three times. We spelled for noon at the last crossing, and struck good going in small jack pine and poplar about two o'clock. High hills. There was a fine view, we could see Salt Mountain range to the east and southeast. Hugh big poplar country lay to the north and west across big valley. We followed the crest of the hills around until we were able to cross to big poplars. Saw fresh buffalo track in jack pine shortly before camp, and camped in big poplar. Fine feed for horses was here, fine thick grass growing everywhere between the poplars. It is great grazing country.

Saturday, October 12, was fine, windy and cloudy at night. McCallum and I went west along a poplar ridge following the old trail. We left horses and dogs, and saw many signs, very fresh, of buffalo, tracking one big bull who had wandered in a circle. It was a splendid country, having big open poplars with open grassy glades and numerous water-holes. We had the bad luck to scare off three buffalo. There must be many buffalo in the country, as the whole country is tracked up, but no calves' tracks are seen.

In the afternoon we baked, and mended mocassins. Although we started out with seven or eight pair of mocassins, we were completely out of footwear. Such things as moose-skin wrappers and gun-coats are requisitioned for shoe-soles. With care a pair of mocassins will last two days travelling in the woods, sometimes not even that. As mocassins cost from $1.50 to $3 per pair, travelling in the bush in summertime is very expensive in regard to footwear. This could be greatly alleviated by having huskie boots, or muk-luks, such as the reindeer men wear, sent in from outside.

Sunday, October 13, was fine. Starting westward again without the pack animals, we made a big circle, following along the line of dry sloughs at the edge of the poplars, then wheeled north into the poplars and then struck home. Buffalo tracks were everywhere, and a band must stay here all summer. Fine feed was found all through the poplars.

Monday, October 14, was fine and warm. All things considered, we decided to head north and northeast. Big poplars lasted for a couple of hours, then big jackpine commenced. Here in the jackpine we struck the trail which I had travelled over on my first journey into the country with an Indian called David Bigar, although I did not recognize it as such until some time later. This is the same trail as the Royal Northwest Mounted Police, accompanied by Radford, used on their trip into this country, and seems to be used every winter for dog-sleds. The peculiar thing which we remarked was that no traps of any kind had been used. This trail, however, will be inspected this winter.

Crossing a big scrub prairie I made a wrong turn and got to the winter road. It was a bad time for a spill, as it follows a line of sloughs. But McCallum went

investigating and found the old track again in the big poplars to the north. Poplar ridges and then big jackpine till we camped by a small grassy slough.

Tuesday, October 15, was fine. We continued west and northwest on the old trail. We found short pieces of muskeg and high jackpine and poplar ridge. At the crossing of double creek, we recognized the old trail. After coming to the huge poplar country, we lost the trail at an open place in the hills. We passed through fine grazing country, long fine grass but no water. Had no noon spell and no water. We struck north through the big poplar hills in search of water, and camped at a small slough at the edge of the poplars. Muskeg or small spruce country lies to the northeast.

Wednesday, October 16, was cloudy with rain at night. I started back to see if I could find the old trail and was away most of the day, finding one old trail with very large old buffalo head running to the northeast. McCallum reconnoitered to the north and northwest, and found a creek and many fresh buffalo signs. This is the upper reaches of Bear creek. This fact I found out later from enquiring and from deduction. The creek flows into Little Buffalo river where we were trapping last winter, before Christmas. Rain fell all night.

On Thursday, October 17, soft snow and rain fell. It was too wet and miserable to travel, and snowed and rained all day. We spent the time mending mocassins and baking.

Friday, October 18, was cloudy. Following the edge of the poplars where the thick small spruce commences, we circled around northwest, then west, then southwest, following the course of the creek. We came at noon spell to a crossing, where a deep buffalo path leads in and out at either side. The crossing was stony and shallow. We spent the noon spell without crossing, and picketed our horses in a small slough near the creek bank. In the afternoon McCallum and I went back along the trail, which is the one we had lost two days before, and made a big circle to the southwest. We saw a big lake or lakes with a big stretch of hay sloughs where Bear creek has its source. It is a high poplar country all around—a fine buffalo country. There must be a big bunch of buffalo here, as there are lots of fresh signs. We followed the creek home, getting lost many times, and finally stumbled into camp long after dark.

Saturday, October 19, was cloudy with snow flurries. We crossed the creek at shallow, stony rapids. Swampy ridges were the rule. It is a very different country to that I saw when out with David. The country has all dried up. Places, on trail where at that time we had to make wide detours, sometimes lasting half a day, were dry as a bone; particularly in one place near Bear Creek where one of the horses lost an eye in plunging about in a bog hole, we were able to cross with no difficulty whatever.

Jackpine ridges and poplar country now alternate. The buffalo path through the jackpine is deep and wide, but in the poplars, where feed is plentiful, its identity is in places nearly lost. Many buffalo have used this trail very recently, as their tracks, both large and small, were clearly marked in the muddy places on the trail, which is not well marked in the small poplar country. Near nightfall we camped without water or ice. It was cold at night.

Sunday, October 29, was cloudy. We had an early morning rush for water. McCallum was unsuccessful, but I located a good spring a mile or so back of the trail. Fine water. Later McCallum went to search for the trail which had been lost again. I baked and mended my mocassins, later McCallum came back and said he saw a big buffalo bull that ran away to the northwest.

Monday, October 21, was bright and sunny. The slight fall of snow had made it very wet and cold underfoot. We made a big circle to-day without the horses or dogs. Going northwest for a short distance, we came to a thick strip of big spruce. This is a well defined strip and is uniformly wooded. Some trees would measure three

feet across the stump and are tall and clean. Beyond, or to the northeast, in which direction we now headed, we encountered small jackpine. We struck an old, well defined buffalo trail here and followed it. It led us westward through small poplar and jackpine, then big poplar. Then about noon we came to open prairie country dotted with willows growing in clumps. In the centre of this, for we can see big timber all around, is a big open meadow covered with long grass with a big slough at the east end. The mud around this slough was all cut up with buffalo tracks, and everywhere were signs that they had been feeding there in bands. Towards nightfall we discovered where two of the animals had been a few hours before. So we followed them through the poplars and jackpine southwards. Although we used a certain amount of caution, we came close to them feeding among the willows, one lying down and the other moving around. Unfortunately, when we first saw them we were on the windward side and very close to them, not more than twenty yards away. Both of them were bulls, not very big, two or three years old, I should imagine. Their coats were thick and a rich dark brown, and they didn't look as if they were worrying much about wolves or feed for the winter. One of them smelt us at once, running his tongue over his nose and wrinkling it up to snuff the air. Then, turning his head to one side, very slowly he moved over to his companion. Then all at once with a snort and a flirt from their tails they were off like a shot from a gun. Their progress was anything but slow and could be heard for a long time after they started. It's almost incredible the speed these animals attain in dense bush. Their clumsy rolling gallop and unwieldy hump doesn't seem to impede them in the least. For them the nearest way is the shortest when galloping; trees, bushes, everything give way to them and the cracking and crashing could be heard a long way off.

With some difficulty we found the trail to camp, and late at night I took the horses to water.

Tuesday, October 22, brought mist and frost on the bushes. Now, as our grub was getting low, we had to head homewards. Knowing the trail as I did, I calculated that we could get home in five or six days at the most; that is, if after crossing the Little Buffalo river, we headed south or southeast over the top of the mountain, following the crest of the Jackpine hills until we struck the trail coming from the shack. This was what we had agreed to do. But McCallum got sick of ploughing through the deep snow and plunging in among snow-laden bushes, for a heavy snow started on Wednesday, October 23, and continued for four days, and we, with much objecting on my part, headed for the face of the mountain, intending to get on the Salt plains and follow the edge of the mountain southeast to our shack trail. I will not record our wanderings and experiences for the last four or five days. They were rather more than hardship. Suffice to say that on Wednesday, October 30, after starving for the last day and going on half rations for the preceding two or three, we managed to reach the shack and grub.

The face of the mountain is impassable and the plain is very much broken up with sloughs, bog-holes and deep creeks. Three wolves' tracks following a cow moose and calf were seen on the big plain. Although we did not see very much evidence of wolves, I have heard since I returned to the Fort that they are rather more numerous than last year.

We have been busy since we returned getting ready our winter outfit, and, as we will have two dog-teams this winter, I expect we will be able to cover very much more country. McCallum has already made a trip to the shack on Salt mountain and back, setting bait out for wolves.

Our next trip, the first with dogs, will likely be into the southern, or Peace River, country, which I think has been rather neglected. The hard frost has not arrived as yet and the muskegs and sloughs are not solid enough for travel.

Respectfully submitted,

GEORGE A. MULLOY.

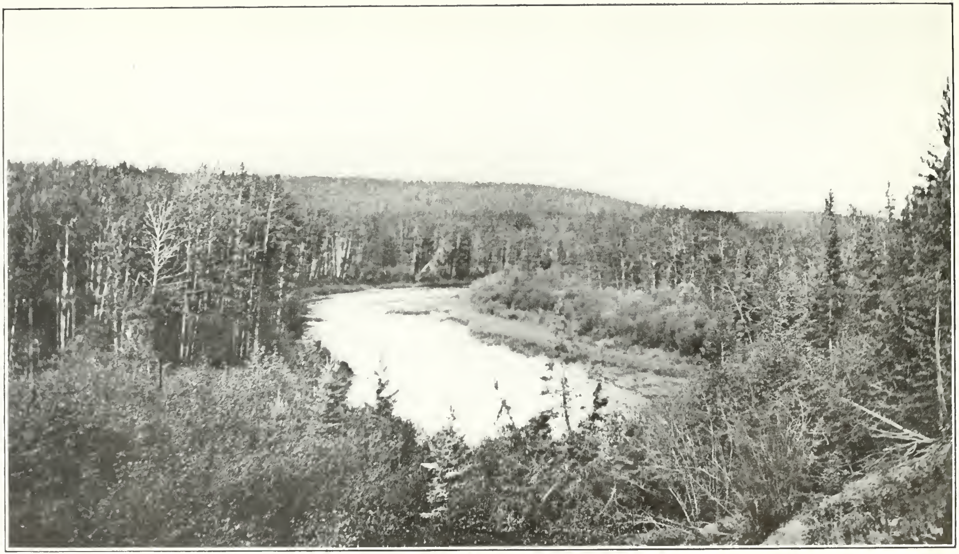


Photo S. H. Clark.

Forest on the LaBiche River.

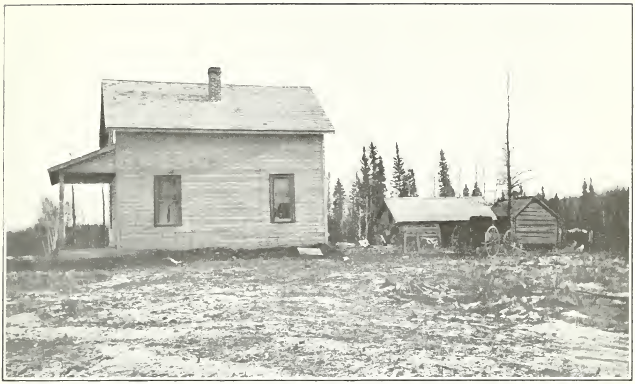


Photo T. W. Dwight.
Ranger Station at Kamsack, Sask. (Duck Mountain Forest Reserve).

Photo E. H. Finlayson.
Forest of Aspen (White Poplar), Balsam (Black) Poplar and Ash in Southeastern Manitoba.

25—1914—vi—9½.

Photo L. C. Tilt.
Growth of Open Jack Pine Reproduction, with Mature Timber in the Background, (Southeastern Manitoba).

Photo J. A. Doucet.
Young Forest in Athabaska Valley (Grande Prairie Road).

Photo A. Knechtel.

Post-box Used by Forest Rangers on Nelson River.

Photo A. Knechtel.

Forest Rangers of Norway House District.

Photo N. M. Ross.
General View of Buildings at Indian Head Forest Nursery Station.

Photo N. M. Ross.
Russian Poplar Test Plantation, Indian Head Forest Nursery Station.

Photo N. M. Ross.

Sample Plot of Siberian Larch (planted 1908) Indian Head Forest Nursery Station.

Photo N. M. Ross.

Sample Plot of Jack Pine (planted 1908) Indian Head Forest Nursery Station.

Clearing on the Forest Trail, Bow River Forest, Reserve.

Photo L. C. Tilt.

A Forest Lookout Station on the Brazeau Forest.

Sheep River Bridge, Bow River Forest.

Pack-train Leaving the Head-quarters of the Brazeau Forest.

Photo W. N. Millar.

Graded Trail in Clearwater Forest.

Photo L. C. Tilt.

Young White Spruce Growing on Site of Abandoned Homestead in Southeastern Manitoba.

25—1914—vi—10.

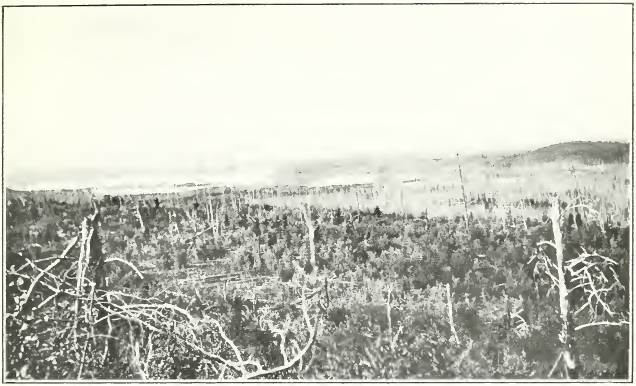


Photo S. H. Clark.

Young Jack Pine Springing up after Fire, Buffalo Lake (Lac LaBiche Region).

Photo C. H. Morse.

View on Crooked River, Lac LaBiche District.

Photo E. C. Wellman.
Fire-guard and Telephone Line on Duck Mountain Forest Reserve.

Photo E. C. Wellman
Deepdale Lookout Tower, Duck Mountain Forest Reserve.

Photo E. H. Finlayson.

Railway Right of Way, Well Cleared.

Photo E. H. Finlayson.

Railway Right of Way, very Poorly Cleared.

Photo C. H. Morse.
Poplar on Agricultural Soil, Sturgeon River District, Sask. (Tp. 52, Rge. 4, west of 3rd meridian).

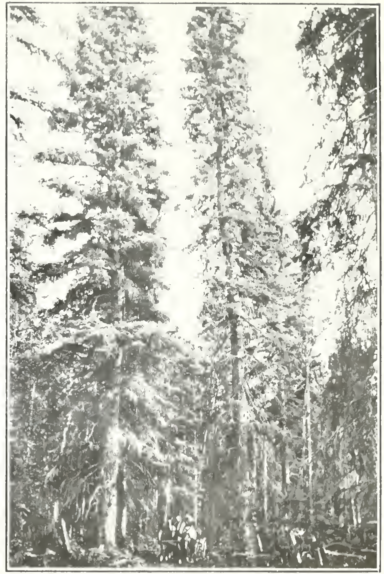


Photo C. H. Morse.
Spruce in Sturgeon River District, Sask. (Tp 52. Rge. 5, west of the 3rd meridian).

Photo C. H. Morse.

Burned Jack Pine, Sturgeon River District, Sask.

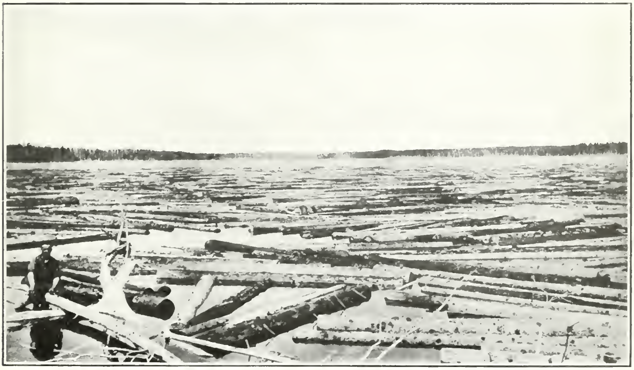


Photo C. H. Morse.

A Log-pond in the Sturgeon River District, Sask.

PART VII

IRRIGATION

REPORT OF THE SUPERINTENDENT OF IRRIGATION.

Irrigation Branch,
Ottawa, May 27, 1913.

W. W. Cory, Esq., C.M.G.,
Deputy Minister of the Interior,
Ottawa, Ont.

Sir,—I have the honour to submit the report of the Irrigation Branch for the year ended March 31, 1913, together with the report of the Commissioner of Irrigation and other officers in charge of the several divisions of the work.

For several years past the work of irrigation administration has been carried on under the supervision of the Director of Forestry, but in October, 1912, owing to the increasing volume and importance of the work, a separate branch was established and the undersigned was placed in charge, with the designation of Superintendent of Irrigation.

The increasing demand for water for domestic, industrial and irrigation purposes, due to the rapid settlement of the West, and the completion of a portion of the Canadian Pacific Railway Company's large irrigation project near Calgary, Alberta, have necessitated considerable increases in the field and office staff at Calgary. The permanent office staff now numbers fourteen and the permanent field staff twenty, in addition to which there are some fifty temporary assistants, drivers, cooks, &c., employed during the season in which field work is carried on.

One cause, although not the main one, of the increasing volume of field work is the policy which the department has followed for several years past in making an annual inspection of all irrigation works, both under construction and licensed. That this policy is in the public interest, and that it meets with general approval is evidenced by a resolution passed at the last convention of the Western Canada Irrigation Association held at Kelowna, B.C., in August, 1912, by which the provincial government was requested to so amend its laws as to provide for similar inspections being made of all irrigation projects in that province.

The extension of the field work has naturally added greatly to the volume of office work and this, in so far as the Calgary office is concerned, is illustrated by a graph included in the Commissioner's report. I regret that inadequate office accommodation has, up to the present, prevented the necessary additions being made to my staff at Ottawa, as the increased field and office work in the West has materially increased the work here.

The scope of the work carried on by this branch is thoroughly covered by the reports submitted herewith, and it is, therefore, unnecessary for me to do more than refer briefly to some of the more important matters that have been dealt with during the year. The work may be roughly divided into the following classes:—

Administrative work at Calgary.
Inspection of Irrigation Projects.
Stream Measurements.
Special Hydrographic Surveys.
Drainage Investigations.
Administrative work at Ottawa.

CANADIAN PACIFIC RAILWAY IRRIGATION PROJECT.

In April, 1904, authorization was granted to the Canadian Pacific Railway Company to construct a system of works for the irrigation of portions of a tract of some 3,000,000 acres of land lying along the main line of its railway east of Calgary. A period of fifteen years was allowed for the completion of the works. For administrative purposes the company divided this block of land into three sections, known as the eastern, central and western sections. The works in the western section were constructed first, and, in August, 1911, the company notified the department that the works in this section were completed and ready for the inspection required by law precedent to the issue of a water license.

As the season was then far advanced and as no funds were immediately available for carrying on the work of inspection, the company was informed that the work would be undertaken during the season of 1912. The completed works in the western section comprise some 1,600 miles of canals and ditches, with the structures necessary for the delivery of water, and were intended to provide for the irrigation of some 363,000 acres of land which the company had classified as irrigable.

Nearly coincident with the company's application for an inspection of these works, complaint was made to the department by certain of the water users on the irrigated tract that the works as constructed were not adequate for the purpose intended, and that some portions of the land classified and sold by the company as irrigable were not irrigable at reasonable cost. It was further alleged that irrigation was, generally, unnecessary in this tract and, because of differences in climatic and soil conditions, that it was not so beneficial as elsewhere in southwestern Alberta and Saskatchewan. The complainants asked the department to have a thorough inspection made of the works, to reclassify the lands said to be irrigable from them and, generally, to take such steps as might be considered necessary for the protection of those who had purchased alleged irrigable land and who had agreed with the company to take and pay for water for its irrigation.

The inspection of works of such extent and cost, under these conditions, was not to be lightly undertaken, and efforts were immediately made to secure the services of a thoroughly qualified engineer who, by reason of his past experience, could be relied upon to deal thoroughly and impartially with the questions involved. Mr. W. G. Bligh, M.I.C.E., was finally selected for the work. Mr. Bligh is a retired officer of the Indian Civil Service, and has had an extended experience in the construction and operation of irrigation works in India, Burma and elsewhere; he is also the author of a standard text book on the design and construction of irrigation works.

Mr. Bligh spent some fifteen months in a study of the conditions affecting irrigation in this tract and in the actual inspection of the constructed works and the land to be served by them. His completed report, together with that of the Commissioner, under whose supervision the inspection was made, is now ready for submission, but has not yet been dealt with.

At a later date, and while the inspection was actually being made, further complaints were made by the water users, through an association known as 'The United Farmers of Alberta,' and, after some correspondence, a conference was arranged at Ottawa between representatives of the company, the water users and departmental officials, with a view to arriving at some settlement of the questions at issue that would be satisfactory to all concerned.

This conference was held in my office on February 12, 1913, and there were present on behalf of the company: Mr. J. S. Dennis, Assistant to the President; Mr. P. L. Naismith, General Manager of the Department of Natural Resources; Mr. G. L. Walker, Solicitor, and Mr. A. S. Dawson, Chief Engineer. On behalf of the water users: Mr. Geo. Zimmerman, Solicitor; and for the department: Mr. F. H. Peters, Commissioner of Irrigation; Mr. K. R. Daly, Assistant Law Clerk, and myself.

After a thorough discussion it was found impossible to reconcile the conflicting interests and to arrive at an amicable settlement, although some progress was made. The respective parties were, therefore, requested to submit written statements setting forth their views of the questions at issue, and a further conference was arranged for the following day with the minister.

On February 13 a final reference of the points at issue was made to the Minister All the gentlemen above named were present and, in addition, Mr. R. B. Bennett, M.P. for Calgary, was present at the request of the Minister. The case was thoroughly discussed, and the Minister's decision was given informally at the conclusion of the discussion. The final decision, which was communicated to both parties by letter dated February 17, was to the following effect:—

1. The company will be required to file such additional plans as are required by the Irrigation Act and as may be necessary to enable the Minister to determine whether a license may properly be issued.

2. The department assumes that the company will continue to operate its irrigation system pending a settlement of the questions at issue.

3. The department reserves the right to intervene in any litigation between the company and purchasers of irrigable land who are also lessees of water, should such a course appear to be necessary for the full protection of the latter.

The filing of additional plans is for the purpose of enabling the Minister to examine into the classification of irrigable land. It is the intention to have the accuracy of such plans tested and resurveys made if necessary; also to have each parcel of alleged irrigable land carefully examined and the classification revised where necessary. Arrangements are being made for a thorough inquiry that should finally settle the differences existing at present between the company, the water users and the department.

SOUTH SASKATCHEWAN DIVERSION PROJECT.

The question of water supply in the Moosejaw-Regina district in southern Saskatchewan has become exceedingly critical. The streams are few and small, and the time is fast approaching when the rapidly growing cities and towns will have outgrown these sources of supply and be forced to look elsewhere for water.

Some two years ago the provincial government applied to this department for a reservation of 100,000,000 gallons of water per diem from the South Saskatchewan river for the purpose of furnishing an adequate water supply to this district. The reservation was made, but no steps were taken by the province, or by the cities chiefly interested, to obtain precise information as to the practicability and cost of bringing water from that stream. Reconnaissance surveys were, however, undertaken by engineers of this branch in the latter part of 1912, from which it appears that a practical route can be found, but that the cost of the necessary works will be very great. Further surveys are to be carried on during the present year for the purpose of definitely locating the pipe line and securing such other information as may be found necessary. A full report of the work carried on during 1912 is attached hereto.

In the latter part of March, 1913, a commission was appointed by the provincial government of Saskatchewan to investigate the feasibility of diverting water from the South Saskatchewan river for the purpose of supplying water and power to the cities in the southern part of the province. The chairman of the commission, Mr. A. J. McPherson, has applied for and has received a copy of the report of surveys made by this branch, and will be furnished with any other available data in our possession relative to this question. Similar information has also been supplied to Mr. L. W. Rundlett, City Commissioner of Moosejaw.

ST. MARY-BELLY RIVER DIVERSION PROJECT.

The pioneer irrigation company of Western Canada—The Alberta Railway and Irrigation Company—draws its water supply chiefly from St. Mary river at a point a few miles north of the international boundary, in township 1, range 25, west of the fourth meridian. There is a considerable area of land susceptible of irrigation in the district served by this company's works, and the practice of irrigated farming—and particularly the raising of alfalfa—has been found profitable. The St. Mary river does not, however, under the most favourable conditions, furnish an adequate supply of water, and the company's works have not, therefore, been extended so as to provide water for all the land that might profitably be irrigated from them.

Some twenty miles to the westward of the St. Mary, the Belly river flows north-easterly in a parallel course. There is little land that can profitably be irrigated directly from Belly river, and its waters are, therefore, not used to any great extent. Surveys made during the past year indicate that water can be diverted from Belly to St. Mary river at reasonable cost and thence utilized through the canals of the Alberta Railway and Irrigation Company for the irrigation of thousands of acres of fertile land in the Lethbridge district. These surveys were not made in the interests of the Irrigation Company, as might perhaps be assumed, but for the development of irrigated farming in the Lethbridge district and to demonstrate the possibility of fulfilment by this government of certain obligations to supply water to the company in lieu of the proportion of the flow of St. Mary river which will be taken by the United States in accordance with the provisions of the Waterways Treaty.

INTERNATIONAL WATERWAYS TREATY.

In 1909 a treaty was made between Canada and the United States in settlement of disputes and differences which had arisen over boundary waters. Provision is made in this treaty for the equal diversion between the respective countries of the waters of St. Mary and Milk rivers, in the State of Montana and the provinces of Alberta and Saskatchewan. Both streams are international in character. St. Mary river rises in Montana, a short distance south of the international boundary, and, flowing into Canada, empties through the Saskatchewan into Hudson bay. Milk river also rises in Montana but, after flowing for some one hundred miles through Canadian territory, recrosses into Montana and empties, through the Missouri, into the Gulf of Mexico. The treaty provides that the waters of these streams, including all their tributaries, shall be divided equally between the two countries, although Canada may take a greater portion of her share from St. Mary river and the United States a similarly greater portion from Milk river. Gaugings have been regularly made of the flow of these streams and of their more important tributaries by both countries for several years in order to determine as accurately as possible the quantity of water available for diversion. These gaugings have heretofore been made independently by either country, but the necessity for co-operation has now become apparent.

Arrangements were made within the past year between the Commissioner of Irrigation and officers of the United States Geological Survey for the establishment of joint gauging stations, one on St. Mary river and two on Milk river in Canada and one on Milk river in Montana. These stations have been built on designs approved by both countries, are equipped with automatic self-recording water gauges and are open to use by officers of both countries, the expense of building and maintaining the stations being shared equally. In this way it is expected that disputes as to the quantity of water available at all seasons may be avoided and the division of the water between the countries simplified.

SOUTHERN ALBERTA LAND COMPANY.

A paragraph in the annual report of this branch for 1911 intimated that this company expected to have its canal system in partial operation within the following year. This has, however, been found to be impracticable. During the summer of 1912 the diversion dam in Bow river was partially destroyed by flood and the intake and portions of the main canal near that point were badly damaged. The company called in expert consulting engineers to advise as to the reconstruction of the dam and diversion works and to pass judgment upon the design and construction of the entire system.

As a result of this the company has reorganized its engineering staff, and purposes relocating its intake and making a number of changes in its canal system. These changes and the rebuilding of the damaged works will involve heavy expenditure—approximately $1,300,000—but will, it is believed, make the system much more effective. The completion of the project will of necessity be deferred for a considerable time.

FLOOD RECORDS.

The reports of Mr. P. M. Sauder and Mr. G. H. Whyte on floods in the Bow and North Saskatchewan rivers are timely and interesting. The investigations were made at the request of engineers engaged in water-power development or the construction of bridges on these streams, and with a view to showing the maximum flood discharge as nearly as it can be calculated from the available records.

IRRIGATION DEVELOPMENT.

The present condition of irrigated farming in the provinces of Alberta and Saskatchewan is dealt with in the reports of Messrs. French, Duffield and Chambers, who were employed as inspection engineers, and whose duties brought them into close touch with those engaged in farming in the irrigated district. Among the suggestions made by these officers one, by Mr. Duffield, is particularly timely. Mr. Duffield suggests the possibility of conserving some portion of the flood run-off of streams in the Cypress Hills district, and is of the opinion that reservoir sites can be found in which a considerable portion of this now wasted water can be held and applied to beneficial use. This is now receiving attention, and surveys will be made during the present year for the purpose of locating suitable sites. The desirability of undertaking this work has also been brought to the attention of the department by the 'Cypress Hills Water Users' Association,' an association formed within the past year for the encouragement of irrigated farming in the district surrounding Maple Creek, Saskatchewan.

The potentialities of such an association cannot well be over-estimated, and there is every reason to expect that this new association may exercise a beneficial influence in its district.

REVENUE.

Attached hereto is a statement of the revenue received on account of this branch during the year ended March 31, 1913. Owing to the fact that the Forestry and Irrigation Branches were not separated until October 1, 1912, it was considered inadvisable to make any change in the accounting system until the close of the fiscal year. The irrigation revenue has, therefore, been dealt with and accounted for by the Forestry Branch, and this statement is, in part, a duplicate of the revenue statement submitted by that branch.

STATEMENT OF REVENUE RECEIVED BY IRRIGATION BRANCH FOR FISCAL YEAR 1912-13.

Received from.	Amount.
	$ cts.
Lethbridge Agency	270.85
Calgary Agency	2,961.12
Medicine Hat Agency	3,712.50
Swift Current "	534.10
Moosejaw Agency	286.25
Maple Creek Agency	173.17
Calgary Agency	24,693.59
Irrigation Office, Calgary	862.00
Total	$33,493.58

The revenue received from the several land agencies consists entirely of payments on account of land purchased or leased under the irrigation system; that from the irrigation office at Calgary covers fees for the issue of water licenses, and for the registration of documents, the issue of permits, etc.

Respectfully submitted,

E. F. DRAKE,
Superintendent of Irrigation.

IRRIGATION OFFICE,
CALGARY, ALTA., May 9, 1913.

E. F. DRAKE, Esq.,
Superintendent of Irrigation,
Department of the Interior,
Ottawa.

SIR,—I have the honour to submit herewith my annual report of the work done under my charge during the year 1912 on irrigation and Canadian irrigation surveys.

I have the honour to be, sir,
Your obedient servant,

F. H. PETERS,
Commissioner of Irrigation and Chief Engineer.

REPORT ON IRRIGATION AND IRRIGATION SURVEYS.

BY

F. H. Peters, A.M. Can. and Am. Soc. C.E., D.L.S., A.L.S.,
Commissioner of Irrigation.

The work of irrigation inspections is to a very large extent a matter of routine which is carried on in the same manner from year to year, so that it is not necessary in this report to give any detail description of the manner in which the work has been carried out. If reference is made to the writer's report submitted for the year 1911, there will be found in the first pages thereof a general description of the manner in which the work is carried on, and these remarks cover the ground quite thoroughly.

As regards the irrigation surveys, several very important surveys were carried on during the past year, and a short reference will be made to these further on in the report; and a full report on the work of the surveys is also included from each of the engineers in charge.

INCREASED APPROPRIATION FOR YEAR 1913.

It is very pleasing to note that a considerably larger appropriation has been granted for the work to be done during the year 1913 than was granted for the work to be done during the year 1912, and this has made it possible for putting the work on a more sound basis and creating an efficient organization which will be able to handle the work which it is called upon to do in, it is hoped, a proper manner. It is difficult to explain in a few words the very large amount of work which this office has to handle, but when it is realized that this office handles the granting of all water rights for every purpose, excepting that of power, in the two large provinces of Alberta and Saskatchewan, and when it is further realized that now is the time that all the large

grants of water for irrigation purposes are being made, it can readily be understood that a very efficient and conscientious organization is required in order to properly guard the natural water resources of the two provinces and to regulate these questions in such a way that they will be able to stand the test of future years, when water rights will have become a very valuable asset.

The proper regulation of the granting of water licenses is one which presents endless difficulties, and it is not a procedure which can be reduced to the following of a number of set rules. The whole question of the granting of water is primarily based on the stream measurement work, to determine the amount of water that under average conditions is available for distribution, and as these records can only be thoroughly relied upon after a long series of yearly measurements, it should be understood that the granting of water licenses based on these records, which are still incomplete, is a somewhat dangerous procedure, and, therefore, the very greatest care has to be exercised on this account.

CYPRESS HILLS IRRIGATION DISTRICT.

The Cypress Hills irrigation district, which in former reports has been referred to as the Maple Creek district, is the one in which irrigation development at present is most active, and on this account this district has during the past few years required a very thorough supervision.

During the past two years this district was handled by having two irrigation parties in the field, under the charge of a division engineer, who made frequent trips of inspection, visiting the two parties, and also was employed in handling the most difficult cases which arose from time to time. During the coming year it is intended to do away with the position of division engineer for this district and to supervise the district with two field parties, each under the charge of a competent engineer who is thoroughly familiar with the irrigation practice in this district.

It is most pleasing to note the interest which has been taken in irrigation in this district, and this has been evidenced during the past winter in the formation of the 'Cypress Hills Water Users' Association.' Because of the interest which has been shown by the formation of this association, and because of the very large irrigation interests in this district, great care has been exercised in selecting the engineers to supervice this district; and the Commissioner feels confident that the two officers selected will be very competent to not only carry on their work of inspection, but also to give sound and practical advice to the many irrigators in this district, who may require such in laying out their ditches, and the construction of their dams and other structures.

DETERMINATION OF THE LOW, HIGH AND FLOOD DISCHARGE OF STREAMS.

Reference is made to the discussion under this heading in the writer's report for 1911, which gives a short description of the data which are required in this connection.

These computations were actively undertaken during the past winter, and while the results which have been gained are of very great value, a great many difficulties were met with in carrying out this work.

The main difficulty that was met with was on account of the varying run off which takes place during each different year. The figures which must be entered on the registers of stream flow must, of necessity, be *average* figures, and thus, in dealing with the flow of a certain stream extending over a series of years, where the amount of flow is very widely different for each year, it is extremely difficult and requires great study to determine the average figures which can be officially used and which will represent average conditions truly.

The necessary figures were computed for a large number of streams where the records were available for periods of at least four or five years, but in many cases the

records were not available for this length of time, or else were so variable in quantity that it was found impossible to get average figures which would represent true conditions, and in all such cases where it was not considered that the figures gained would be reliable, the question was held in abeyance until some future date when sufficient data will have been gained to allow reliable figures to be computed.

OFFICE WORK.

In order to get an idea of the large amount of office work which is required, it should be kept in mind that as the granting of a water license is something which is to hold and determine for all time to come, it is a matter which must be most carefully considered and one which requires a large amount of work in keeping the proper books of record corrected and up to date.

Another point which is probably not realized by a person not familiar with the work is that the greatest part of the correspondence carried on by this office is with farmers who are not familiar with business methods, and who are not good correspondents, and this, while apparently a very small matter, is a condition which adds a great deal of work in connection with the correspondence carried on by this office.

A very large amount of office work is also required to keep the records of stream measurements up-to-date and in proper shape. To understand this, it should be realized that about 160 cards of 'gauge height observations' are received at this office each week from the various gauge height observers. These cards all have to be checked over and the information taken from them and placed on the proper office form for purposes of record. A good deal of correspondence springs from this source in writing to the observers to get records which were not submitted, or in order to get satisfactory explanations of gauge heights that cannot perhaps be deciphered in the office. Again, all the hydrographers are required to send in their note books of stream measurements when they are filled up and these also have to be checked and curves plotted from them, and then filed away so that the information may be available for the hydrographers when they return in the winter for the purpose of working out the records from their summer field notes.

The office staff, generally, has throughout the past season been overworked, owing to the fact that the staff employed was not large enough to handle the work properly, but this condition as has been previously noted will be rectified during the coming year.

The following list gives a summary of the correspondence, plans, documents, &c., that were handled in the office during the fiscal year ended March 31, 1913.

Letters received	9,279
Letters sent out	13,614
Applications for water rights recorded	58
Plans with applications for water rights, in duplicate	57
Right of way easements recorded in triplicate	44
Other agreements	7
Right of way plans recorded, in quadruplicate	61
Water agreements filed, in quadruplicate	560
Notices of cancellation of water agreements in triplicate	147
Notices of transfer of water agreements, in triplicate	151
Applications to cross road allowances recorded	21
Applications for free right of way over Crown lands recorded.	16
Notices for publication prepared	58
Blue prints made	4,873
Plans prepared	307
Certificates issued under Section 20 of the Irrigation Act.	47
Certificates issued under Section 33 of the Irrigation Act.	61

Number of licenses recorded, in triplicate..	62
Reports received and dealt with..	551
Weekly reports received from engineers..	968
Reports of discharge measurements (Form H. 4) received.	2,095
Weekly reports of gauge heights (Form H. 2) received.. ..	4,975
Descriptions of regular gauging stations (Form H. 1) received..	37
Reports of changes at river stations..	71

It is thought that the work of the office is shown in a true manner by the number of letters handled, that is, the total number of letters received at the office and sent out from the office, and in order to show the great growth of the work in the office, a simple illustration has been prepared in the form of a graph, showing with different columns the total number of letters handled in this office from the year 1902 to 1913.

FUTURE WORK OF THE IRRIGATION OFFICE.

Considerable space was taken up under this heading in the writer's report for the year 1911 and as these remarks all hold equally true at the present time, it would be a mere repetition to discuss the questions again in this report.

It is, however, noted with great pleasure that the amount of the appropriation voted for the coming year's work has been increased so as to permit of the work being done in a much more thorough manner than has been possible in the past, and among other items, an amount has been made available for carrying on experiments for the determination of the proper 'Duty of Water.'

DETERMINATION OF THE PROPER DUTY OF WATER.

The term 'experiment' used in this connection is a somewhat unfortunate one because it naturally conveys to the mind some operation which is highly complicated and technical, and usually such results, particularly among the agricultural class, are looked upon with suspicion; in carrying on this work in Canada the endeavour will be made to keep away as far as possible from any work which will be of a highly technical or experimental nature, the endeavour being, on the other hand, to get the data wherever possible from watching and studying conditions as they exist under the methods which are commonly used by good farmers.

It must be thoroughly understood that nothing in these remarks is meant to cast any reflection on the most excellent experimental work which has been done along these lines by several different organizations in the United States, because this work has been very highly developed in many cases and has resulted, during the last few years in a very much better understanding of the proper use of water for irrigation being gained than was ever the case in prior years. Very fortunately, the results of all these experiments have been made public so that the officials of this department are able to avail themselves of the information which has been gained, and this very much simplifies the work which it will be necessary for us to do in Canada, because much of this experimental work can be applied to the conditions existing in western Canada, once sufficient information along these lines has been gained to allow us to use, as it were, a proper coefficient, or in other words, to determine the changes that must be made in order to suit our own particular local conditions of soil and climate.

WORK DONE DURING THE YEAR 1912.

The work done during the year 1912 has consisted of carrying on the usual routine work of irrigation surveys and the work of stream measurements. As reports from all the field engineers dealing with these different questions in detail are submitted in this report, it is unnecessary for the Commissioner to make any comment on them, excepting to state that the work in all cases was carried on with great diligence and in a most satisfactory manner.

A few words, however, will be said about three large surveys of very great importance which were carried on during the past year.

During the spring of the past year, the Canadian Pacific Railway Company applied for an inspection to be made of the western section of its irrigation block in order that the necessary water license for this scheme might issue in due course. This work was undertaken and completed but the report which has been submitted in connection with it being very voluminous, is submitted separately, and does not form a part of this report. This work, covering a part of the largest irrigation scheme in America, necessarily meant dealing with a great many of the larger and broader questions affecting irrigation which usually are not met with in the smaller schemes, and for this reason, entailed a large amount of work.

The 'South Saskatchewan Diversion Project' is a scheme of very great magnitude, and of the greatest importance to all those persons living in that area in the province of Saskatchewan lying south of the Qu'Appelle river, where the question of gaining a sufficient supply of water for domestic uses is a most critical one. This project is most fully discussed in the report which is being submitted by Mr. R. J. Burley, who had general charge of the work.

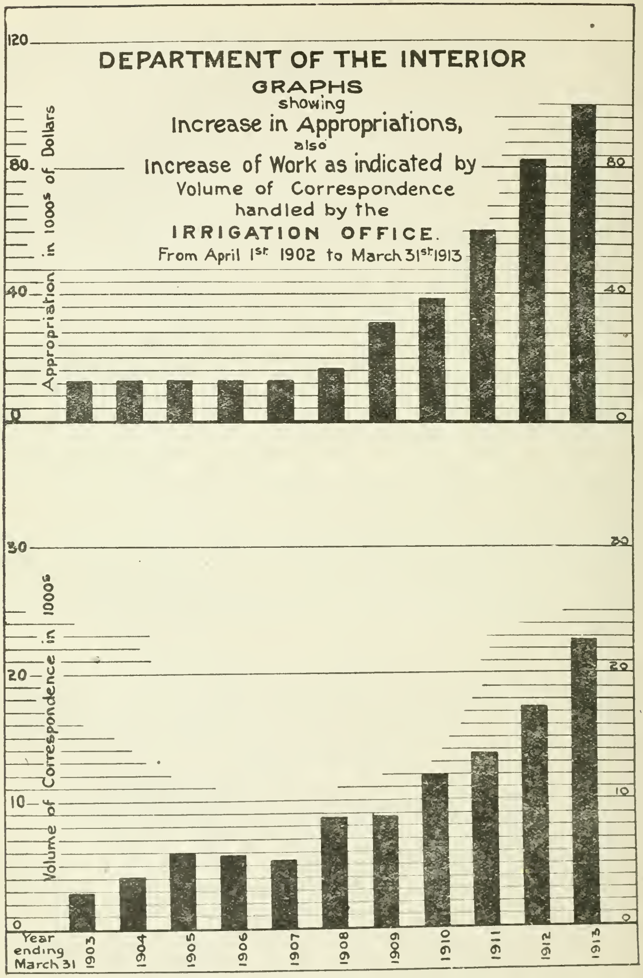
Some years ago the Alberta Railway and Irrigation Company was granted certain rights on the Milk river and St. Mary river in southern Alberta and owing to certain conditions which have arisen since that time, it has seemed probable that there will not be available from these rivers the amount of water which will be required in the future by this company. For this reason, it became necessary to determine the feasibility of supplying an additional quantity of water from some other source, and a complete survey was therefore made to show the feasibility and cost of diverting water from the Belly river into the St. Mary river at a point a few miles north of the international boundary. This question has been very fully taken up in the report submitted by Mr. B. Russell, who had charge of the field party on this work.

APPRECIATION OF THE WORK OF THE STAFF OF THE IRRIGATION OFFICE.

In concluding this report the Commissioner wishes to express his thanks and appreciation to every member of his staff for their hearty and conscientious co-operation which alone has made it possible to carry on the successful season's work during the year 1912.

Respectfully submitted,

F. H. PETERS,
Commissioner of Irrigation and Chief Engineer.


DEPARTMENT OF THE INTERIOR
GRAPHS
showing
Increase in Appropriations,
also
Increase of Work as indicated by
Volume of Correspondence
handled by the
IRRIGATION OFFICE.
From April 1st 1902 to March 31st 1913
Appropriation in 1000s of Dollars
120
80
40
0
Volume of Correspondence in 1000s
30
20
10
0
Year ending March 31
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913

EARLY HISTORY OF IRRIGATION IN WESTERN CANADA.

When any large question has become of importance and is of general interest to the public, its early history is always of great interest and a short account is therefore given here of the early history of irrigation in western Canada.

This account is a short extract taken from the report of William Pearce, D.L.S., then Superintendent of Mines, to the Commissioner of Dominion Lands, and dated at Calgary, October 31, 1894.

'In compliance with your request, I herewith have the honour to submit for your information a report on irrigation matters for the past year so far as the same have come under my notice.

'It might be well at this juncture to give a brief resumé of the history of irrigation in the Northwest Territories.

'The first irrigation ditch constructed was probably by Mr. John Glen, who in the year 1875, settled on what, upon survey, proved to be section three, township twenty-three, range one, west of the fifth meridian. The ditch was constructed in, I think, 1878 or 1879, and was in active operation in 1880. The water was taken out of Fish creek and an area of probably 15 or 20 acres irrigated. Owing to the faulty construction the ditch was not, from an engineering point of view, a success; but as long as Mr. Glen occupied the place it proved a very valuable aid in his farming operations, although its maximum usefulness was not utilized for the reason above stated.

'There are the remains of a ditch on what is now the Peigan Indian reserve in the bottom of the Old Man's river about a mile and a half above the agency. It was constructed by two Americans who had squatted there prior to this reserve being formed. They were, I am informed, bought out and probably left the country. I do not think any water ever flowed through this ditch, except during the overflow of Beaver creek, by which it was intended to be fed.

'I am told that there is an irrigation ditch near the Cypress hills built many years ago; but I am unable to find out who constructed the same or whether it was ever utilized. The remains of it, however, can be distinctly traced, it is stated.

'On sections 35 and 36, township 18, range 29 west of the fourth meridian, a ditch was constructed by Messrs. Smith & French. This was taken out early in the eighties; but it was found useless, as the water was at a lower elevation than the land it was intended to serve. A small outlay would, however, have made it work.

'In 1889 water was taken out of Big Bear creek, which rises on the north slope of the Cypress hills and empties into Crane lake, by a ditch to create some hay-lands. It is stated to have been a success. At its inception the work was very faulty, but has probably been greatly improved.

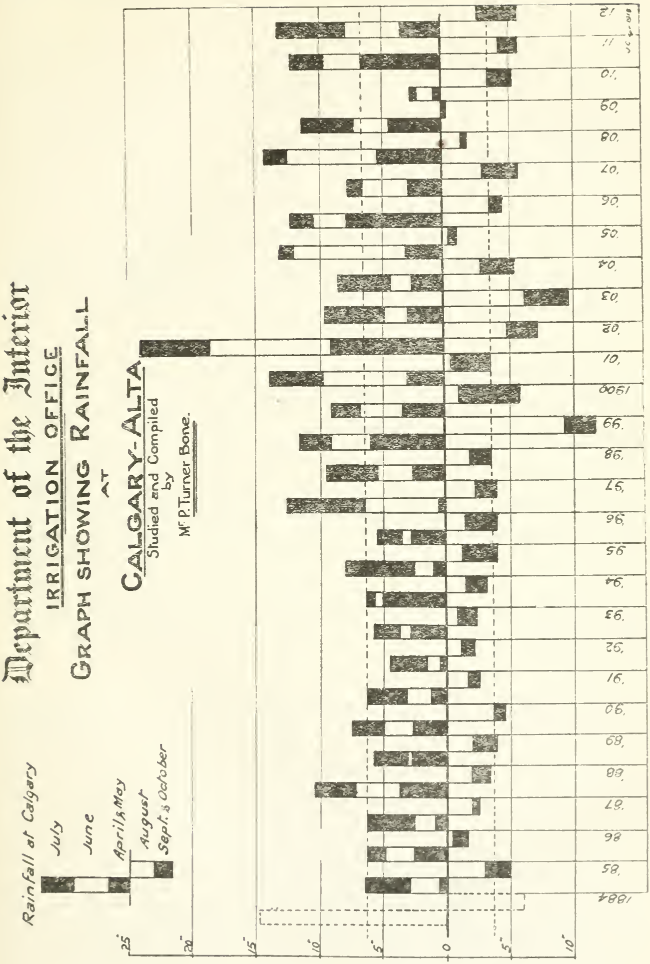
'The next ditch constructed in the territories was in, I think, the year 1891, by Mr. John Quirk. The water was taken out of the north fork of Sheep creek on about section 5, township 20, range 4, west of the 5th meridian. In 1892 he had probably 100 acres under irrigation. But he has since extended it considerably. This ditch has been a decided success and a great object lesson in irrigation for the settlers of that portion of the territories.

'Since 1892 a very large number of ditches have been constructed of various sizes and great interest has been displayed in the subject.

'The first irrigation company chartered by Act of Parliament in Canada was in 1891 when the MacLeod Irrigation Company received its charter.

'In 1892 the "High River and Sheep Creek Irrigation Company," was incorporated and the Alberta Railway and Coal Company's Act was so amended as to enable them to construct irrigation works and practise irrigation thereunder. In 1893 there were three charters granted. "The Alberta Irrigation Co.", "The Calgary Hydraulic Com-

pany," and the "Calgary Irrigation Company." In 1894 the "Calgary Irrigation Company" obtained an amendment to its charter and the "General Irrigation Act," known as the "Northwest Irrigation Act," became law, and it is probable no more charters will be granted as the general Act is broad enough to cover everything necessary in such enterprise.'


Department of the Interior
IRRIGATION OFFICE
GRAPH SHOWING RAINFALL
AT
CALGARY-ALTA
Studied and Compiled
by
Mr P. Turner Bone.
Rainfall at Calgary
July
June
April & May
August
Sept. & October
25"
20"
15"
10"
5"
0
5"
10"
1884
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
1900
01
02
03
04
05
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11
12

REPORT OF R. J. BURLEY ON THE MAPLE CREEK DISTRICT.

March 1, 1913.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Calgary.

SIR,—I have the honour to submit herewith my annual report of last season's field operations in the Saskatchewan division of the irrigation surveys.

Owing to the resignations of Messrs. F. T. and W. A. Fletcher at the end of the fiscal year, Messrs. French and Duffield were appointed to carry on the work of inspection in the Cypress Hills district during the past season. Mr. Duffield was assigned to the western portion, and Mr. French to the eastern—each working in a manner similar to that employed during the previous season.

PARTIES.

Each party consisted of an engineer in charge, an assistant engineer, two rodmen, a draughtsman, a cook and a teamster, the western party having been enlarged to the same size as that in the eastern district in accordance with my recommendation of last year. Each party was equipped with five tents, one wagon, two democrats, eight horses, together with the necessary cooking utensils, tools, &c., for a party of seven men.

After Messrs. French and Duffield were relieved from hydrographic work they took charge of their parties and commenced their work as outlined in their instruction sheets, moving their camps to the points from which their work could be carried out to the best advantage. The details of the method employed in carrying out this work and the location of their camps, &c., are outlined in each of their reports, so that there is no necessity of discussing it here.

During the first part of June a special trip of inspection was made over the more important works in the two districts with the Commissioner, and in several instances in which matters presenting difficulties had arisen, he was able to personally inspect and adjudicate the trouble.

DAMAGES CAUSED BY FLOODS AND ICE JAMS.

During the fall and winter of 1911-12 there was an unusually heavy precipitation over the Cypress Hills with the result that the streams were running abnormally high when the winter set in, resulting in the formation of thick layers of ice, and, when the thaw came suddenly in April, the extraordinarily large run-off of snow water reached the main drainage channels before this ice had thawed or rotted to any degree. This resulted not only in an extreme flood but also in a run of ice which proved very destructive to irrigation works, bridges, &c., especially along the main drainage channels, such as Frenchman river, Battle, Lodge and Middle creeks, and in many cases the damage has seriously embarrassed applicants financially and will prove the cause of delay in the completion of the works.

It is probable, however, that this misfortune will prove of benefit eventually, as it has shown very conclusively the weakness of construction in many schemes and most of the applicants whose works were damaged are now planning reconstruction on a much better basis and are concluding that permanent structures properly designed and constructed are the cheapest in the end. During the past summer and

fall a good many have been going into the question of costs of concrete, metallic flumes and first-class wooden structures, and there is no doubt that when railroad communication is available on the south slope of the Cypress Hills, the owners of the majority of the larger schemes will replace temporary structures with concrete and steel.

Messrs. Duffield and French are including in their reports details of the damage done, and it is interesting to note that in all but one case the losers were not sufficiently discouraged to throw up the scheme. This fact tends to show that more than a perfunctory interest is taken in the question of irrigation, and that while in many cases the construction is not of the best, nevertheless these men are sufficiently interested to give a hopeful outlook for the future of irrigation in the district.

PROGRESS OF WORKS.

The larger schemes on the main drainage basins were badly handicapped during the past season, in so far as progress was concerned, by the spring flood damage necessitating a great deal of repair work, but on the whole the progress made has been satisfactory, seventeen schemes having passed final inspection and twenty-four others being in such shape that only a few minor details remain to be completed.

A great improvement can be noted from year to year in the method employed in the construction of the schemes and, gradually, larger supply ditches, better distributary systems and a more intelligent application of irrigation principles are supplanting the old, haphazard methods which usually prevail in a new district. More men year year are becoming interested in alfalfa growing and intensive farming, and are planting experimental crops. This work takes a great deal of time and is more or less discouraging unless some means can be arrived at to disseminate the knowledge gained; for experimenting without some guide usually results in more failures than successes, as there are generally a great many wrong ways of doing a thing and only one right way. A demonstration farm managed by a thoroughly experienced and practical man, using irrigation under the conditions peculiar to the district, would be of inestimable benefit to all the irrigators in the district, and would greatly increase the success of the work.

Irrigation is now passing through a transition period in this district and, as there is practically no inducement to the speculator, owing to most of the easily acquired parcels of land being taken up, from now on most of the applicants will either take up irrigation wholly for the benefit it confers, or will drop it as a means which has served its purpose. It remains with the Department to encourage them and keep before them the advantages which will accrue to themselves from the intelligent use of water. This course will hasten greatly what might otherwise take a long period, as it has in the United States, viz.: the conservation and proper use of the available water supply.

WATER USERS' ASSOCIATION.

During the past season the question of a water users' association was discussed with several of the more prominent irrigators and an attempt was made to organize early in May, but owing to lack of advertisement very few of those interested came into town for the meeting and it was deferred to a later date. In the meantime the matter was talked over with a good many of the men interested and was taken up by yourself and Messrs. D. J. Wylie, M.L.A., and R. G. Williamson, with the result that a very good meeting was held on January 27, with an attendance of about fifty.

At this meeting it was decided to organize under the name of 'The Cypress Hills Water Users' Association,' and to affiliate with the Western Canada Irrigation Association with the idea that questions of purely local interest should be taken up

and dealt with by the Association, while matters which would be of interest to others in the three provinces would be brought to the attention of the Western Canada convention by the appointed delegates.

The whole territory covered was divided into ten districts, each having a representative on the executive who is expected to look after the interests of the irrigators in his district, and to present such questions to the Association as a whole, as would appear to advance irrigation interests.

At the organization meeting above referred to, four resolutions were passed, two of which refer to the work of this office and read as follows:—

(1) 'Whereas it is the opinion of this convention that irrigation is not carried out in the best manner possible in this district,—and whereas the conditions of stream flow are such that they preclude the possibility of utilizing more than a fraction of the annual flow for irrigation or other purposes,—and whereas the excessive floods cause great damage both to irrigation works and to other interests,—and whereas there are numbers of reservoir sites on the various watersheds in the district which can be utilized to remedy these conditions,—therefore be it resolved that the Dominion Government be strongly urged to institute and carry on from year to year such surveys as may be necessary to demonstrate the feasibility of reservoir sites on the various watersheds along which irrigation is practised and to estimate the capacity and cost of such reservoirs.'

(2) 'Whereas there are now over two hundred independent irrigation schemes in this district, all of which have business with the Department's representatives,—and whereas advice is frequently required regarding different matters arising in connection with these schemes,—and whereas the irrigation office at Calgary is at such distance as to make it extremely difficult for the majority of the members of this Association to visit this office for the purpose of personal discussion of the question arising—now therefore be it resolved that the Minister of the Interior be requested to establish a sub-office of the Irrigation Department at some central point in this district.'

The first one respecting reservoir site surveys takes up a question which is undoubtedly of great interest to all irrigators in the Cypress Hills and one which has been taken up at length by the writer in several previous reports. There is no question that until some action is taken in respect to this matter, irrigation cannot reach its fullest development, and further, unless such surveys are carried out by the Department, it is doubtful whether any extensive action can be taken by the irrigators themselves in the way of construction, as they are not in a position to have the necessary examinations for feasible sites made. In the case of the larger sites where the water is to be utilized over a larger area of country there is very little doubt that the cost of construction must be met by some other method than by the irrigators benefited bearing it all. In such cases provision must be made to carry the peak of floods, such as occurred last spring, into the reservoirs, so preventing the destructive results which follow them and in this way benefitting a great number of people not only by overcoming dry periods but by avoidance of losses due to the effects of a quick run-off.

The second resolution is one which was fully discussed and has many points to commend it. The general feeling appeared to be that such an office would greatly facilitate the transaction of business between the Commissioner of Irrigation and the applicants, as it is always much easier to come to an understanding of a situation by conversation than by correspondence, and a man on the ground in touch with local conditions would be in a very good position to judge as to the correctness or otherwise of any claim.

SOUTH SASKATCHEWAN RIVER DIVERSION SCHEME.

About the first of July it was decided to carry the work of developing a preliminary line in connection with the proposal to divert water from the South Saskatchewan river to supply the needs of Moosejaw, Regina, and the surrounding districts, and during that month a party of thirteen men was engaged and the necessary camp equipment, transport, &c., purchased.

Mr. T. M. Montague, B.Sc., was placed in charge of this party and work was commenced in the latter part of July, continuing till November 15. As a complete

report of this survey is being submitted it is unnecessary to enter into details as to the work done, methods employed and results accomplished, but possibly a short résumé of the necessity for and advantages of such surveys would not be out of place.

At first sight the proposal to divert water from this river, pumping it over the height of land and constructing hundreds of miles of expensive pipe-line involving the expenditure of millions of dollars, appears visionary and almost absurd, but a closer study of the conditions prevailing throughout southern Saskatchewan shows that this is far from being the case.

Here is a district containing thousands of square miles of the finest agricultural land, two cities and numerous towns having all the necessities for the formation of large communities but even now beginning to feel the shortage of water and beginning to look about for a permanent supply. A study of local conditions has already shown conclusively that such supplies are both inadequate and unsatisfactory from the fact that this water is of very poor quality both chemically and from a bacteriological standpoint. Again the railways are finding it increasingly difficult from year to year to handle their traffic across these divisions owing to the shortage and poor quality of the water and are expending large sums, piping spring water long distances, and running numbers of tank cars during the winter months.

If this condition continues but one result can follow, and that is the cessation of development, for the present per capita consumption of water is as low now as it can be brought and no community can expect to thrive or to attract industries and manufactories unless it has an ample water supply not only for domestic purposes but also for industrial and fire purposes.

The diversion of water from the South Saskatchewan is the only solution yet suggested which will fulfil the two fundamental demands, viz.: abundance of water, and water that is suitable for all purposes.

The question of expense is the only drawback and, while this will doubtless be high, there is no doubt that the great advantages to the district will more than repay any expenditure made on this account.

The following summary shows in tabulated form, the main details of the season's work:—

Number of inspections	33
Number of reports submitted	40
Number of days, rain or snow, exclusive of Sundays—April 28 to October 26	36
Number of miles driven—April 28 to October 20	2,642

I have the honour to be, sir,
Your obedient servant,

R. J. BURLEY,
Division Engineer.

REPORT OF M. H. FRENCH, ON THE EASTERN MAPLE CREEK DISTRICT.

CALGARY, ALBERTA, February 28, 1913.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following report of the work done by myself and party, in the eastern section of the Maple Creek irrigation district, for the season of 1912.

After reporting to Mr. R. J. Burley on May 6, I assisted in the assembling and outfitting of the party, which work, with the exception of three inspections and one traverse survey, took until May 24. On that date I moved my camp to the ranch of Mr. I. H. Williams, where the season's work really began. From there camps were established successively at the following places:—

Hay Creek, at Peacock's ranch	June 10
Bear Creek, Skibbereen P. O	June 24
Skull Creek, near Skull Creek P. O	July 9
Pollock's Butte, east end	August 1
Galienne Coulee at Strong's ranch	August 20
North Fork Frenchman River at Cross' ranch	Sept. 10
Fairwell Creek at Drury's ranch	Sept. 25
Battle Creek at Stirling's ranch	Oct. 14
Battle Creek, at Richardson's ranch	Oct. 29
Belanger Creek, in Williamson's field	Nov. 9

The party was disbanded November 27, the equipment stored in the government store house at Maple Creek, and the horses returned to Needham's ranch for the winter. A short trip of reinspection was made by myself to east end, returning to Maple Creek December 5, which ended the season's work.

Before proceeding further, I wish to state that due credit should be given to the above-mentioned persons for kindly giving us the use of their pastures for camping grounds as this accounted chiefly for the excellent condition of our horses throughout the summer. We also saved considerable time thereby in not having need to look for suitable camp locations, which are now very scarce, due to the settled condition of the country. I also wish to refer to the excellent equipment and personnel of the party placed at my service by Mr. R. J. Burley, as, to this fact, in a great measure, was due the smooth running of the party and the consequent amount of work. The name of H. M. Goodman should be favourably mentioned for his valuable assistance in handling the office work.

The season's work was conducted very much along the same lines as in previous years. Practically no change was made in the personnel of the party, equipment, method, and territory covered, with the exception of the addition of an extra man and of that country lying along Maple Creek, north of the Canadian Pacific Railway. The chief aim was to cover the inspection work of the district and obtain as many accurately amended general and detail plans of the different schemes as time would permit.

As we were favoured with average weather through the summer, followed by an open autumn, most of the work laid out was accomplished.

To give a fair idea of the general method of conducting the work I will describe the method of procedure. In locating our camps easy accessibility to the different schemes within a radius of not to exceed fifteen miles was given the first consideration after which in importance was suitable pasture for the horses. After establishing a camp in any locality all schemes in need of amended general and detail plans were taken up first. Data for the amendment of the general plans were obtained by transit traverse of all constructed works and boundaries of all irrigable areas such as creeks, foot of hills, &c. In running these traverses it was found that in most cases more work per man could be done by using five men than a less number, as considerable stadia work was also done without delaying the party. The inspection of the scheme was made at the same time, and data obtained for the amendment of the detail plans. The party generally returned to camp each night. When enough data had been obtained to keep the others busy in camp for a few days working up the notes, preparing the general plans, and doing any other office work required, I would take a rodman and complete the inspections of the other schemes, writing up my reports during wet weather or on other days when there was nothing urgent on hand. In this way no time was lost by any man in the party.

No hydrographic work whatever was done by the party throughout the season as all the streams were very steady, and the district hydrographer was covering the district thoroughly about every three weeks. For this reason I considered the time better utilized in strictly irrigation work. A few gauging stations were established in those ditches that were completed and where the applicants could divert any considerable quantity of water.

In regard to establishing some system of accurately measuring the flowing water in those irrigation ditches with little slope, I have come to the conclusion that a gauge rod placed a few feet above a submerged weir is the most convenient as well as the cheapest method to the irrigator. The discharge at any point of a stream is controlled to a great extent by a certain cross-section below, and varies appreciably with the changing conditions of the cross-section. That point of control will, in the ditch, be the submerged weir, the crest of which will be above the top of all grass or weeds which grow in all channels of little slope, and also above all dirt and débris which generally collects, or slips into the channel. This weir should not be high enough, however, to restrict very much the cross-section of the channel. The discharge is not to be obtained by the use of submerged weir formulæ, which would be too approximate in this case, but a discharge curve for the gauge rod is to be obtained in the usual way by meter or weir measurements above or below the submerged weir. I am not advocating this method as superior to the rating flume in obtaining results, although I consider it sufficiently accurate to all intents and purposes, but from the point of cost to the irrigator.

In the case of the rating flume, if the floor is not placed above the inevitable growth of grass and collection of débris in the channel below which acts as a changing point of control, the results will be almost as erroneous and deceiving as from any other cross-section.

Wherever the slope of the ditch will warrant it, I would strongly recommend the immediate construction of weirs, as they are certainly superior from the standpoint of accuracy, convenience to hydrographers, and cost to irrigators to any system. Although they are open to one objection, that of filling up behind with silt and débris, a little attention with a spade in small ditches will overcome this defect.

As the irrigators must do this at their own expense, I would suggest that plans for same be drawn up in the office for their guidance. I would also suggest that nothing smaller than 3-inch plank or 4-inch x 6-inch posts be used in their construction, as permanence is the chief consideration.

Some such method as described will have to be adopted if accurate results are desired, as the present system of merely using the natural cross-section of the channel is, with few exceptions, ill-adapted to the small ditches in the Maple Creek district. If the growth of grass affects appreciably the cross-section and discharge of streams like Battle Creek, how much more will it change conditions in a small ditch.

Considerable progress in irrigation has been made in the district, not only in the further completion of many of the schemes but also in the general status of irrigation in the minds of the people. This is evidenced strongly by the recent formation of a water-users' association. They are beginning to see the results of the beneficial application of water to the land from a financial standpoint. Irrigation has now passed that initial stage of development when water was applied to natural hay meadows through small ill-designed works in a haphazard way. They now realize that money spent in good substantial structures and in the enlargement of the ditches, and the substitution of cultivated grasses for the natural grass is a profitable investment. When any industry or undertaking is considered in that light there need be no doubt as to its future development.

Concrete is being used now in the construction of dams, headgates and road-crossings, long-span steel trusses are taking the place of the old, short wooden ones which were generally destroyed during a high flood. The day of brush and rock dams in streams of any considerable size and ice movement, is passed and, although they are still in use, they are to be replaced by something more substantial whenever the irrigators are able financially to do so. It is the duty of the field engineers to encourage and suggest the replacing of these temporary structures by those designed in the office. Of course this will tend to throw the responsibility for the success or failure of any structures upon the Department. There need not be much trouble from that source however, if the work is done exactly according to plans, as the members of the staff are in a better position to secure ideas of proper design than any irrigator unable to afford the services of a competent engineer and who would otherwise build his structures according to his own vague ideas of what he saw done in some other district or country. A very striking example of this occurred in my district this last season which ended very disastrously to the irrigator.

The winter of 1911 and 1912 was noted for its depth of snow on the ground and thickness of the ice in all the creeks. It was followed in the spring with several days of warm weather, causing a sudden break and an unusually quick run-off. Not only did the water get exceedingly high, but it was filled with large chunks of ice which proved very destructive to all structures along the creeks, most of which were either seriously damaged or totally destroyed. The trouble in two cases was the movement of the ice before there was sufficient water in the stream to float it clear of the crests of the dam, with the result that the crests and wings were crushed down. The trouble in other cases was due to the insufficient carrying capacity of the spillway of the dam. The damage to the flues was caused by the ice crushing out the supports which were inadequately protected or braced. This can be remedied in many cases by using longer spans and placing the supports higher up on the banks.

The following is a summary of the damage done:—

Structures.	No. Damaged.	No. totally destroyed.	Loss.
Dams	8	4	$7,610 00
Flumes	1	5	1,180.00
Headgates		2	300.00
Dykes	2		500 00
Ditches	2		600.00
Total damage	....	....	$10,190.00

To arrive at some idea of the actual cost of the services of the party per working day, I have arranged the following figures:—

Total salaries of party..	$2,550 00
Interest upon cost of equipment 3½ per cent of $3,210..	112 35
Twelve and one-half per cent depreciation upon part of equipment valued at $2,270..	283 75
Thirty-three and one-third per cent depreciation upon part of equipment valued at $940..	313 33
Cost of provisions in camps..	470 00
Miscellaneous expenses..	520 00
Total..	$4,249 43

This does not include the district engineer's expenses or overhead charges. The amounts are not accurate to a dollar, but are close enough for the purpose.

Number of days engaged in actual field or office work with a camp of seven men..	100
Number of days with a camp of four men..	50

As the cost of a camp of four men is about 70 per cent of the cost of a camp of seven men, the fifty days for four men may be called equivalent to thirty-five days for seven men, or 135 in all.

The cost per day for seven men is therefore..	31 48
The cost per day for four men is therefore..	22 04

The following is a summary of the year's work with the addition of a few other figures which may be of interest:—

Number of inspections..	105
" reinspections..	10
" new applications..	10
" schemes recommended for license..	10
" schemes recommended for cancellation..	7
" schemes for extension..	40
" licensed schemes..	55
" miles travelled by team..	3,748
" miles travelled per day per team..	5
" miles traversed..	125
" days traversing above, including the inspection of the schemes, &c..	52
" general plans drafted in camp..	18
" days with rain or snow, exclusive of Sundays..	26
Cost of provisions..	470
Number of meals served in camp..	3,060
Cost per meal..	15·4c.

CROP REPORT.

Excellent results have been obtained by a few irrigators in raising cultivated hay with irrigation. This is very encouraging for the future of irrigation as a means of producing an abundant quantity of cheap forage for the winter feeding of stock. Since the country has been opened up and settled by homesteaders, the great need of the stockmen is grass. They have been forced to reduce their herds to correspond to the summer range and, to take the place of the winter range, winter feeding must be adopted to a considerable extent. Thus practically all the irrigation done to-day is carried on by ranchers in their efforts to obtain a sufficient supply of hay. Very little grain is grown under irrigation unless it is to be cut green for feed.

Due to the amount of precipitation in the hills during the irrigation season there was very little marked difference between irrigated and non-irrigated grain. The yield of wheat upon dry land was in many instances over thirty bushels per acre and I doubt if any irrigated wheat went much better than that. The only difference that could be noticed in oats was that the straw of the irrigated oats was much ranker.

In the production of hay, however, there was a very noticeable difference. The yield of wild hay from dry land did not exceed ½ ton per acre while that from irrigated land equalled 1½ tons per acre. Cultivated grasses such as bromus, western rye, and timothy did well this last season; averaging about 2 tons per acre and running as high as 3½ tons in one instance. Alfalfa can hardly be considered beyond the experimental stage in this district as no one yet has had any great success with it, while several have met with failure. I would certainly advise any one to go very cautiously in planting any considerable area of land to alfalfa before giving it a thorough test upon small plots of land in different parts of the fields. However, I have no doubt, judging from observations of its growth in different fields in this district and the great success which irrigators have in other parts of the country under almost the same conditions of soil and climate, that it will become the main forage crop upon those fields more favourably adapted to it.

One thing that I would suggest be published and distributed among the different irrigators would be a pamphlet giving in brief the results of the different attempts and results of irrigation in the Maple Creek district, including also views of the more important structures, &c. This would give the people an idea of what their neighbours were doing and would have more weight and arouse more interest than a description of experiments carried on in some other country. The people have very little idea of what is being done along irrigation lines even in close proximity to them and a pamphlet of this nature would at least give them something to think about.

The following is a summary of the irrigation work of the district:—

—	Irrigable area	Area under Irrigation.1912
Total schemes licensed 47	15,560	8,400
Schemes where works are in course of construction.—53	20,386	1,794
	35,946	10,194

The reason that only 50 per cent of the irrigable land of licensed schemes was irrigated was due chiefly to the amount of precipitation in the district during the irrigation season, and partly to the total destruction of the irrigators' diversion dams.

The following is a summary of the acreage under different crops:—

—	Acreage.	Average yield.	Maximum yields.
Native Grass	7,957	1-ton.	2-tons.
Western Rye	260	2-tons.	3½-tons.
Bromus	190	2-tons.	3-tons.
Alfalfa	87	1-ton.	2½-tons.
Grain	1,700		
Total	10,194-acres		

Your obedient servant,

M. H. FRENCH.

DISTRICT.

IRRIGATION OFFICE,
CALGARY, ALBERTA, February 28, 1913.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to present herewith my report of the work done under my supervision on the irrigation surveys in the Maple Creek western division during the season of 1912.

I arrived in Maple Creek on May 8 and took charge of my party on May 25. After outfitting the camp was moved to a spot about seventeen miles to the southwest. From this point the work of inspection may be said to have begun. After inspecting the schemes within reach of this camp, the camp was again moved on to another district where the same method was used. This continued until the whole district was inspected. As this method is familiar to you I shall not follow the subject further, but will instead go into the work carried out by myself and also by my assistant.

HYDROGRAPHIC WORK.

This work was carried out by my assistant, Mr. Hoover. It comprised taking measurements on all streams within reach of the camp. In all there were 27 steam measurements taken. These were taken mostly by a Price motor or, where the stream was not large enough, a weir was used. These measurements should be found very useful as they will supplement the hydrographers' work.

INSPECTION WORK.

The work of inspection was carried out entirely by myself. This may be considered to be the most important branch of the work carried on from the camp. The district which came under my supervision included the area lying between range 26 west of the 3rd meridian, to range 9 west of the 4th meridian and from the international boundary up to township 16. As this is a large area the method of working had to be mapped out beforehand so that every scheme could be inspected with the least amount of travelling. This necessitated the camping grounds being selected so that the greatest number of inspections could be made from each camp with the least expenditure of horse flesh. There were fifteen camping grounds and from these points the inspections and traverses were made. Fortunately the season was good and I am pleased to say all the schemes of the district were inspected.

The camp moved out from Maple Creek on May 25, and kept on the move until November 13, when the party was disbanded. From this on, to December 2, short runs were made both from Maple Creek and Medicine Hat. On December 3 I arrived in Calgary to prepare the work done in the summer.

SCHEMES EXAMINED.

There were 113 schemes inspected during the season, of these 32 are licensed. These can be said, with very few exceptions, to be in fair working order. The remainder are under construction and should be well on to completion when next inspected. The schemes of this district may be said, with very few exceptions, to be 'high water' and 'flood stage' schemes. This necessitates the works being in good condition in the spring so as to withstand the floods coming down when the season begins to open. Unfortunately several of the works of the district were washed out during the flood period of the past season. This, I think, may be attributed to faulty construction of the several irrigators in the methods of making their dams, dykes, &c. It was found without exception that these works were merely thrown up, no attempt being made to break the earth up so as to consolidate the structure. Consequently when the flood came, the water found its way through the small interstices and so starting with a small leak went on until the whole structure was carried away. I think too much attention cannot be paid to this matter; its neglect generally means the dam or dyke being washed away, as happened in the past spring. The majority of the schemes in this district depend entirely on one flooding—in the early spring. This appears to be sufficient, as the crops raised were in most cases of an exceptionally heavy growth. It was also noticed that the farmers seeing the great advantages to be gained from irrigated land were becoming thoroughly interested in the matter. These men are all pleased to see the inspecting engineer on his rounds and generally have more questions to ask than the engineer has time to answer. Unfortunately, the size of this district will not allow the engineer to give to each scheme the time which he would like to give, as he is always impressed with the idea that he must get on. This is unfortunate, but as the district now stands, there is no option in the matter. With regard to the designs of the several structures, such as headgates, flumes, dams, &c. I would recommend that these be standardized as much as possible and that the irrigators should not be allowed to depart from them. I am sorry to say that I found in some cases structures had been erected which did not conform to the authorized plans. This might be overlooked if the structure were built as strong or stronger than that authorized. In some cases the structures were built stronger but in others they were not, consequently they have to be strengthened. In the design of dams, it was found that where the dam had been constructed with earth interwoven with willows that this was in all cases able to withstand the onrush of water in the opening up of the season. This construction appears to be admirably suited for flood water dams or for dams which are subject to sudden rushes. It also has the advantage of being as easily constructed as the solid earth dam; willows, or other small brush generally being found in close proximity. Concrete in small schemes I do not advocate, as the quantity of material necessary to make the various structures is too small to be effective. Any part of the concrete being undermined the whole structure is thrown out of plumb or otherwise displaced. Concrete to be used to the best advantage must be used in larger masses than it can be used on these small schemes. Another reason against the using of concrete is that there are very few farmers who understand its composition and they consequently use poor proportions. The making of concrete is an operation which requires a man thoroughly versed in its properties. Also the farmer will, if left to himself, design works made of this material which are not consistent with good practice. As an instance of this, there are two headgates on schemes near the international boundary; both of these structures have failed solely from no other cause than poor design.

Regarding the reservoiring of water, this is a subject deserving of great attention. An inspecting officer on his rounds through his district cannot fail to see that an immense quantity of water is allowed to go to waste. This water instead of being turned to beneficial use must, as long as present conditions exist, be allowed to pass. Oftentimes it acts detrimentally to the irrigator, carrying away his dams, dykes, &c.,

as has been experienced in the past season. There are several places which appeared to me well suited for reservoir sites. If these could be established, all, or a great part of, the water running to waste could be held back and so distributed as required. By this method of storage a vast quantity of land could be brought under cultivation, whereas in its present state it can only be used for ranching purposes. If the building of reservoirs is ever an accomplished fact, it will of course necessitate the remodelling of the several schemes existing below and obtaining their water from the new structures. This may at first occasion some friction among the irrigators, but when the advantage is pointed out to them, the extra work of remodelling their schemes will, I believe, be carried out without much annoyance. It is to be regretted that this subject had not been settled some years ago, as I am inclined to think the reservoirs will ultimately be built.

SURVEY WORK.

The number of schemes traversed and brought up to date was eighteen. All of these are of small area; the largest being a farm of some two and one-half sections. Besides this there were several details of structures which differed from the authorized plans; these were noted and measured up so that all office records can be kept abreast of the field work.

The number of schemes levelled was thirty-one. Also the irrigators were given all the levels necessary for the carrying on of their works.

The number of new schemes examined and traversed was seven. These have now been further examined in conjunction with the records of the hydrographic office. Two of these schemes I am sorry to say have been found to be unfeasible, as the hydrographic records showed that there was not sufficient water in the district in which these schemes are situated.

GENERAL.

In the inspection of the several schemes in my district I was often at a loss to know what to recommend for license and what to allow to stand over. This state of affairs went on until I had examined more or less one-quarter of the whole district; I then saw that the standard of the district was not so high as I would have liked it to be. This I attribute to the constant change of inspecting officers taking charge of the district and perhaps to a certain extent, to the mildness of the department in allowing a too free extension of time for the completion of the several schemes. It would, in my opinion, have a very salutary effect if a scheme deserving of cancellation were cancelled and not as at present, generally given another year in which to complete. This is a subject which would require judgment on the part of the inspecting officer; also it would require the inspecting officer to have been at least two or three years in the district, so that he could weigh the merits or demerits of each particular case. It is, I am convinced, a very bad policy for any government to adopt a mollycoddle attitude towards any of its subjects and very much more so when the subjects of such a government are allowed to get into the habit of taking all that is to be offered and grudgingly giving in exchange the least minimum. This should be altered. In closing, I am of the opinion that an inspecting officer does not learn his district until he has been at least two years in it. Unfortunately, it is generally found that he by this time severs his connection with the department and so the district suffers by his loss. This state of affairs is most unfortunate; there is no reason to show why the several districts should not be models of expert irrigation, and the country brought to a state of the highest cultivation possible. This, I am sorry to say, can never be as long as the constant changing is allowed to go on. No one, I think it may be said with truth, commences to take a keen interest in his work until he sees his ideas being put into shape. This can only take place after a lapse of two or three years in the district.

The following is a summarized list of the work during the season:—

Number of inspections	113
Number of reports submitted	117
Number of days of rain or snow, exclusive of Sunday	15·5
Number of Sundays	27
Number of miles travelled by teams	4,613
Number of miles travelled in inspection work	3,324
Number of traverses run	18
Number of stream measurements taken	27
Number of schemes levelled	31
Number of working days in the field	143·5
Number of miles of traverse run	57·1
Average mileage per team per day	6·07

Respectfully submitted,

HUGH J. DUFFIELD.

REPORT OF CHARLES CHAMBERS, ON THE CALGARY IRRIGATION DISTRICT.

Irrigation Office,
Calgary, Alberta, February 22, 1913.

F. H. Peters, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

Sir,—I have the honour to submit my annual report of the progress of the Calgary Irrigation district for the year 1912.

AREA.

The limits of the inspection district extend from the north boundary of township 24 on the north to the international boundary on the south; also from the first range of the Rockies on the west to the Calgary-Macleod Railway and Blood Indian reserve on the east.

FARMING AREA.

The whole district can be practically divided into two distinct areas, one devoted mainly to the raising of grain and feed, and the other to the raising of cattle and horses, and the growing of hay and green feed for live stock. The former, the farming area, lies adjacent to the railway track, extending to a distance of nine to twelve miles to the west of it. The land is more or less flat. In this area the main grain crops grown are wheat and oats. The wheat grown is principally winter wheat.

The soil in the district to the north of Cowley is heavy clay and admirably suited to the growing of large yields of winter wheat of the best grade. Winter wheat is also largely grown in the Pincher Creek district. The soil from High River to Claresholm is generally a light loam and both spring and winter wheat crops are grown in this area.

ALFALFA.

Alfalfa has not been grown on a very large scale hitherto and then only when assisted by irrigation. Mr. W. J. McLaughlin of High River, has put an area of 80 acres under alfalfa. In the autumn of 1911 after ploughing, discing, and well working the ground, he gave it a long watering, soaking the soil well; he then left it until the spring, when he sowed the seed. The crop in the autumn of 1912 was well advanced and a success.

Mr. Lane has 250 acres of alfalfa under cultivation in township 14, range 29, west of the 4th meridian, but unfortunately it has not been very successful this year. Messrs. Drumheller & Coolidge, of Nanton, have very carefully prepared 100 acres of land by ploughing and then several times discing and harrowing the surface until it has been brought to a fine tilth. They then propose to irrigate the soil well and sow alfalfa seed in the spring. The soil is a rich black loam and the surface practically level. The position of the land, the nature of the soil, the advantage of irrigation, and the manner in which the experiment is being carried out, bids well for it to become a success.

On an average two cuttings and sometimes three of alfalfa can be made each year. The yield is approximately three tons per acre per year.

RANCHING AREA.

The ranching area extends from the limits of the farming land to the first range of the Rockies and consists partly of rolling land and partly of very hilly land.

Prairie wild hay, green oats, timothy and bromus, for feed for cattle and horses, are the principal crops grown in this area. It is found that irrigation of the wild prairie hay gives double the yield, and that it is sometimes as much as two tons per acre.

With the exception of about 1,500 acres on the Peyisko ranch, which Mr. Geo. Lane sowed with wheat, very little grain has been raised in the ranching area. Although as a rule the soil is suitable to its growth, the climate is not. Being so near the Rockies, frequent summer frosts and early frost in the autumn make it impossible, except in very exceptional instances, for the grain to have time to ripen.

HIGHWOOD RIVER FLOOD.

On Saturday, July 20, much rain fell in the Highwood River district, causing an unusually heavy flood in the river. The result was that early on July 21, 1912, the weak nature of part of the river banks a little to the west of the town of High River could no longer withstand the heavy strain on them, with the disastrous result that the river broke its banks and flooded the country round for a considerable area. The water to the west of the railway line and north of the town, not finding the culverts through the railway bank of sufficient size to allow all the water to pass through them to the east, flooded the railway bank, rendering it for a while unsafe for the passage of trains.

Nearly the whole of Mr. R. A. Wallace's land in sections 7, 18, township 19, range 28, west of the 4th meridian, both on the west and east side of the railway line, was flooded with river water.

The left river bank at the point of the intake of Mr. R. A. Wallace's ditch in the northwest quarter of section 1, township 19, range 29, west of the 4th meridian, appeared to me on my inspection on May 8, 1912, to be a weak part. It is a made bank and crosses a dry slough. To strengthen the bank I would recommend stone pitching on the stream face and stone groins run out at an angle to assist in diverting the flood water round the bend.

PORCUPINE HILLS SPRINGS.

During the very dry year of 1910 many of the springs rising in the Porcupine Hills suffered very severely, some of them running completely dry. The effect of this drought has been so great, that many of the springs seem very slow to recover the flow they formerly had. One small creek in particular which had had a flow for years, quickly dried up in 1910 and has not run since. On the last inspection it showed no signs of any flow being likely to take place.

IRRIGATING HEAD.

The sources of supply of any of the irrigation schemes for which licenses have already been granted, although giving a supply of water which will cover the duty required of them, namely two acre feet per irrigable acre per season, have not a sufficient discharge to cover the minimum irrigating head of 2·5 second feet per 80 acres according to the circular dated November 13, 1912.

In order to secure this it will be necessary to form reservoirs where feasible near the head of the ditches, so that sufficient water can be stored to create the irrigating head required.

STREAM DAMS.

In the irrigation schemes that were out of repair it was noticed that in many cases they were mainly due to the dam, which headed up the water in the creek, either leaking or being washed away.

During flood time, the temporary dam being made of rock and cribwork or lumber and brush rip-rap, or having a spillway opening of sufficient area to pass the flood water through except by offering a great resistance, is either washed away, undermined, or a cut made round one of the wings of the dam. It is recommended that in future temporary dams in small creeks be constructed of the type made up of lumber with large spillway openings in which the water is headed up by means of removable shutters or flash boards, rather than that the dam should be built of the rock and cribwork type; the stream thus in flood time has a free flow through the dam without so much obstruction.

INSPECTIONS.

The number of schemes inspected was 149, distributed as in the following table:—

No.	Particulars.	Acreage under irrigation.
115	Irrigation schemes constructed up to date	31,456
19	Irrigation schemes under construction or contemplated	3,309
4	Schemes for domestic purposes	
2	Schemes for industrial purposes	
4	Schemes for water works	
5	Schemes cancelled	
149	Schemes inspected	
	Total	

The number of miles travelled by trail were	2,642
The number of miles travelled by train were	177
The number of right-of-way surveys made were	2
The number of surveys to determine the feasibility of schemes and for staking out work were	11
The number of schemes for which plans were submitted were	14
he number of discharges of streams taken were	31
The number of schemes in which the quantity of material and work have been measured and estimates of costs made were	3

Your obedient servant,

CHARLES CHAMBERS.
Inspecting Engineer.

REPORT OF P. J. JENNINGS, ON SPECIAL INSPECTIONS.

IRRIGATION OFFICE,
CALGARY, ALBERTA, February 25, 1913.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Calgary, Alta.

SIR,—I have the honour to submit the following report upon the work done during the season 1912 on 'Special Inspections.'

TERRITORY COVERED.

The territory covered by this work includes the provinces of Alberta and Saskatchewan, an area of 506,985 square miles. The easterly boundary being the western boundary of the province of Manitoba, the southern boundary, the 49th parallel, or the international boundary, the western boundary the eastern limits of the province of British Columbia, and to the north extending as far as settlement has yet reached.

SCOPE OF WORK.

This year's work has included the inspection of works proposed or works already undertaken, either for—

1. The diversion and use of water for domestic purposes.
2. The diversion and use of water for irrigation.
3. The diversion and use of water for industrial and other purposes.

Inspections have also been made and reports submitted in connection with schemes for the diversion of large bodies of surface waters.

The conservation by storage of the flow, at high and flood stage, of streams that are subject to extreme low flow in both winter and summer.

The investigation and inquiry into protests filed against various applications under the Irrigation Act.

The investigation of complaints against the illegal diversion of the course of a stream.

The illegal obstruction to the flow in a recognized watercourse.

Many minor matters such as the ownership, and control of beds of rivers and streams or of well defined watercourses, &c.

EXTRA ASSISTANCE.

Last year's returns on the work accomplished on special inspections, demonstrated the necessity for further assistance, in order that one inspection, at least, of each scheme could be made. On May 30, Mr. R. H. Goodchild was therefore transferred from the Hydrographic Branch to the Special Inspections section of the Irrigation office. In order to familiarize him with the work and methods followed in the field, it was deemed advisable that he should accompany me on one inspection tour. This idea was carried out and Mr. Goodchild remained with me until the 17th of June, most of which time was spent on actual irrigation surveys.

ARRANGEMENT OF WORK.

In order to safeguard against overlooking an inspection, a map of the two provinces was mounted on a large board, and at each point where an inspection was needed a small white flag with the file number on it was attached to a long pin and erected at this point. By this method I was able to arrange the tours in such a way that a round trip could be made and the schemes within the area taken in, disposed of. As nearly as possible, the number of inspections and area to be covered was so arranged that Mr. Goodchild could meet me at least once a month in Calgary. This arrangement was very successful and the plan was kept up to date by Mr. White, the chief clerk, who, upon receiving a report upon any certain scheme coloured the flag red. By this method, it was seen at a glance what work was actually done, and what remained to be done.

OUTLINE OF THE WORK DONE.

During the season 120 inspections have been made; of these 8 were for domestic schemes,53 for irrigation and 35 for industrial purposes, the balance being in connection with special work such as explained above. Of the total schemes inspected, Mr. Goodchild inspected 45. For fuller information on these, reference can be made to his own report, which is submitted herewith.

PROGRESS ON THE CONSTRUCTION OF THE IRRIGATION SCHEMES AUTHORIZED.

Good progress has been made this year on the majority of the schemes authorized, and in several cases the works have been completed and licenses recommended. The great difficulty with outlying schemes is the scarcity of labour. This not only holds up the farmer and deprives him of the extra yields his land would produce under irrigation, but it necessitates the recommendation of an extension of time in which to complete his works, which of course incurs much correspondence and office work. I have not yet come across an irrigation scheme which has been authorized and completed within one year of the date of authorization. It would therefore seem that the twelve months given an applicant to complete an irrigation project, including as it does several months when no work is possible, is insufficient. But I do not think that it would be to the general public good to alter the present arrangement, although it necessitates considerable office work, for the following reasons:—

1. There are no two schemes alike as regards the amount of work to be done per acre of land benefited.

2. The granting of more than one year from date of authorization would tend to apathy on the part of some in getting their work started.

3. In cases where Crown land is being reserved for sale, it might, in some instances, be the means of tieing up both water and land for an indefinite period, and depriving others of the benefit of the water.

4. In cases where large works are undertaken, the applicant could be given to understand that providing reasonable diligence is exhibited in the execution of the work, there would be no fear of his application being cancelled.

SUMMARY OF INSPECTION TOURS.

An earlier start was made on outside work this year than in previous years, the object being to endeavour to dispose of as many of the railway tanks and other industrial schemes as early as possible so as to be free to devote more time to the irrigation surveys. I left Calgary on 15th April, going north to Edmonton, thence west on the Grand Trunk Pacific railway as far as Edson, thence back to Edmonton. From Edmonton east to Saskatoon, making the inspections at all points on both the Grand Trunk Pacific railway and the Canadian Pacific railway. With Saskatoon as

a centre, each of the branch lines were worked from this point. The next centre was Melville on the Grand Trunk Pacific railway, from whence a number of scattered schemes were inspected. Regina was next visited and from this point each of the branch lines was taken in turn and the schemes inspected. Returning west on the Canadian Pacific railway further stops were made at Moosejaw, Rush lake and Swift Current. On this tour 24 inspections were made and Calgary reached on the 24th of May.

After making a special trip to Wetaskiwin in connection with a dispute regarding the illegal diversion of the creek in the town, I started out on the second tour, leaving Calgary on the 7th June.

This second tour included the district north of Medicine Hat and east along the Saskatchewan river to Saskatchewan Landing, north of Swift Current. Most of the inspections of this tour were for irrigation purposes and several complete surveys were made. Calgary was again reached on the 4th of July, twelve inspections having been made, five of which necessitated complete surveys.

During July, owing to the unusual wet weather, it was only possible to make a few special trips out from Calgary.

Between 23rd of July and 1st of August, a short tour was made into the Crowsnest Pass and some seven outstanding inspections disposed of.

A special trip was made to inspect Reservoir Site 'K' on the south fork of Sheep creek, leaving Calgary on the 2nd of August. On account of the recent heavy rains the journey up the creek was made under very adverse conditions, the trails being very bad and the fords dangerous to cross, on account of the swollen state of the creek. Sufficient information was obtained for a sketch of the location and for a recommendation as to the advisability of retaining this site.

The sixth annual convention of the Western Canada Irrigation Association was held at Kelowna, B.C., between the 13th and 16th of August, and was attended by me.

The annual tour of inspection along the Red Deer river, of the irrigation schemes between ranges 18 and 1, west of the 4th meridian, was undertaken between the 7th of September and the 7th of October. Fourteen inspections and six surveys were made on this tour.

During October, some special inspections were made at Lethbridge and in the Crowsnest Pass. From the 18th of October until the end of the season, 25th of November, I made Moosejaw my headquarters. This was partly necessary on account of the work there in connection with the protests filed against the construction of a new dam in Moosejaw creek by the Canadian Pacific railway.

The illness of Mr. R. J. Burley, about the end of October necessitated my remaining in the vicinity of Moosejaw until the 25th of October. Besides the inspections and investigations which were made in connection with the protest filed against the works being constructed in Moosejaw, the outstanding inspections were made in the district south and east of Moosejaw.

Considerable time was also taken up during Mr. Burley's illness in visiting the parties engaged on the South Saskatchewan river diversion survey. The final arrangements for the transportation of the outfits to Maple Creek, and storage for the camp equipment and suitable winter quarters for the horses were also made.

PUMPING SCHEMES.

A great many of the more recent applications which have been given me to inspect relate to the purchase of land under the Irrigation Act, and consist of pumping projects. In a number of the cases examined it was found that to pump the flow of water deemed by this office as necessary for practical irrigation, the schemes often became impracticable, owing to the high cost of installation and the consequent excessive cost of maintenance and operation.

Where water has to be artifically raised for irrigation purposes, unless the plant is on a very large scale, the supply is usually limited to a somewhat more moderate valume than is generally allowed for from a gravity irrigation project. In Alberta and Saskatchewan where irrigation is carried on under peculiar and almost exceptional conditions, special regulations to take care of these conditions must be enforced to ensure success.

A point which was often brought up by applicants for a pumping scheme was —'why must I instal my plant with a capacity greater than the legal flow prescribed in the regulations?' In most cases this was explained to the satisfaction of the applicant, by pointing out to him the necessity of having a larger head of water at his command when applying it to his land.

It is evident that considerable doubt exists in the minds of many of the ranchers and farmers as to the fairness of the general application of the prescribed 'duty of water' for all parts of the two provinces. As a case in point one applicant, when informed that it would be necessary for him to make such provision in the design of his plant, to enable him to apply 2·023 acre feet per season to his land, immediately informed me that such an amount of water would not be beneficial to his land, and if such was enforced he could not consider the scheme any further.

In my opinion there are many cases where the full benefits of irrigation, that is to say, maximum production, could be secured with a much higher duty of water, but until some reliable experiments on this all-important point have been undertaken in various parts of the two provinces, it is impossible to make any suggestions for amendment to the existing regulations. The experiments that are most needed in connection with pumping schemes are those which would give some reliable data as to the amount of water required for the maximum production of wild hay, blue joint hay, and alfalfa, under say three common soil conditions.

DETAIL OF SCHEMES INSPECTED.

During the season of 1912, 120 inspections were made, 45 by Mr. Goodchild and 75 by myself. The following summary will give the result of the season's work at a glance:—

Inspections made personally	75
Made up as follows:	
Domestic purposes	6
Irrigation purposes	27
Industrial purposes	21
Municipal purposes	5
Special inspections	16

Complete surveys were made for 11 schemes. Plans were prepared in connection with 12 schemes.

Amended plans prepared	4
The season comprised	226 days
Wet days	26
Sundays	32
Available working days	179

The number of available working days divided by the number of inspections shows that each inspection took approximately 2.3 days.

MILEAGE TRAVELLED.

Total number of miles travelled by train was	10,179 miles.
Total number of miles travelled by team was	1,941 miles.
Total	12,120 miles.

COST OF WORK.

The total expenses incurred during the season amounted to $2,513.28, which amount includes salary. An accurate cost per inspection cannot be very well estimated this year, as the above figures include over three weeks spent on the other work; but the approximate cost would work out to about $29 per inspection.

Respectfully submitted,

P. J. JENNINGS, A.M.Can.Soc.C.E., A.M.Inst.W.Engrs.,Lond.,Eng.
Inspecting Engineer.

7th January, 1913.

F. H. Peters, Esq.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alta.

RE CROP REPORTS.

Sir,—With reference to your circular letter of the 3rd inst., re crop reports, I beg to inform you that during last season's work there were only one or two isolated cases where irrigation had been practised, and these schemes were not licensed.

Very little information for a crop report has been gathered. The schemes visited were either industrial, municipal, unfinished schemes or new applications, and would furnish very little, if any, useful information.

Your obedient servant,

P. J. JENNINGS,
Inspecting Engineer.

REPORT OF R. H. GOODCHILD ON SPECIAL INSPECTIONS.

IRRIGATION OFFICE,
CALGARY, ALBERTA, February 18, 1913.

F. H. PETERS, Esq.,
Commissioner of Irrigation and Water Power,
Department of the Interior,
Calgary, Alta.

SIR,—I have the honour to submit the following report of work done by me during the season of 1912 on special inspections.

On the 31st of May, 1912 last, I left Calgary on my first tour of inspection, being joined on June 4 by Mr. P. J. Jennings with whom I worked until June 16, after which time I made the inspections allotted to me alone, completing my last inspection on December 4.

In order to reach the schemes inspected it was necessary for me to cover a large territory, and a great deal of time was taken up, and correspondingly heavy expenses were incurred on this account.

This territory, stretching from the Yellow Head and Crowsnest passes, on the west, to Saskatoon and Weyburn on the east, and south to the 49th parallel, is, in many parts, very sparsely settled, and poorly served with railways, and in order to reach some of the outlying schemes, I had to make drives of from one to two hundred miles, and drives of sixty and seventy miles were frequently necessary.

However, as the railways are rapidly extending their lines, and the country is fast becoming settled, each year will see great reductions in the time taken to reach these outlying schemes, and a corresponding lessening of the expenses incurred in making each inspection.

A large variety of schemes were inspected, pumping schemes for industrial, municipal and irrigation purposes and gravity systems for irrigation and industrial schemes.

I investigated several protests in connection with the diversion of damming of water supplies, but found that the disputes were generally due to misunderstandings or to an ignorance of the meaning of the Irrigation Act, and that, once the meaning of the Act was explained, and a spirit of conciliation established, the matter in dispute was easy of adjustment, and an early agreement reached.

During the season I made fifty-two inspections, seven with Mr. Jennings, upon which he reported, and forty-five while working alone, which I reported in due course.

To do this work it was necessary to travel 5,635 miles by rail, and 1,458 miles by trail, making a total of 7,093 miles.

My work during the season of 1912, may be summarized, as follows:—

Inspections made—52 as below:

Irrigation	29
Industrial	13
Municipal	3
Domestic	2
Special	3
Complete surveys of irrigation schemes made	9

Complete sets of general and detail plans for above schemes prepared	9
Transit traverses run (miles—13·2)	12
Stadia surveys made	2
Amended plans of irrigation schemes prepared	3
Estimates of cost of irrigation schemes made	4
Gauging of creeks made and reported	9
Miles travelled by rail	5,635
" by trail	1,458
Total	7,093

The above mentioned plans were prepared by me, upon my return to the Calgary office after each trip, and the time spent during the season was used, as follows:—

Days lost by bad weather	1
Days spent in travel (approx.)	62
Sundays	27
Days in Calgary, on plans, reports, &c.	32
Days spent in actual field work	67
Total available days during season	189

Fifty-two inspections were made in sixty-seven days, or at the rate of one inspection in 1⅓ days.

The total expense of the seasons work, including my own salary, was $1,522.75 or $29.28 per inspection.

To make each inspection it was necessary to travel on an average of 136 miles, and, in two cases, trips of over two hundred and fifty miles had to be taken to make, in each case, one inspection, so that the above average cost per inspection, though apparently very high, is really not at all excessive.

Respectfully submitted,

R. H. GOODCHILD,
Inspecting Engineer.

VARYING CONDITIONS OF RAINFALL AS AFFECTING PLANT GROWTH IN THE VICINITY OF CALGARY, ALBERTA.

The question of the useful precipitation which falls naturally is one which affects directly the beneficial use of water for irrigation, because irrigation really means the addition of that amount of moisture by artificial means which is required to make up the proper amount of moisture for the successful growing of the various kinds of crops.

In the writer's report for the year 1911, it was realized that the records of rainfall and temperature over the territory where irrigation is practiced, should be very interesting to persons who are interested in irrigation schemes and for this reason all the records that could be obtained were published in tables showing these data for different cities and towns where records have been kept

While these tables are very interesting if sufficiently studied, they do not show at a glance the very great variation in rainfall, and in addition to this, as they show, in columns for total precipitation, all of the precipitation which has fallen during the year, whether rain or snow, it is thought that they do not show truly the condition of precipitation as directly affecting plant growth. In the attached graph an endea-

vour has been made to show only the precipitation which directly affects plant growth, and also to show in a manner very plain to the eye the great variation of this precipitation from year to year, and also to indicate what are commonly known as 'the old dry years.'

The following graph was studied and compiled by Mr. E. Turner-Bone, civil engineer, of Calgary, who has very kindly placed the information at the disposal of the Commissioner of Irrigation.

This graph shows only the rainfall which takes place in each year during the periods from April 1 to October 31, it being accepted as the truth, that snow and other precipitation which occurs during the winter months is of no value for agriculture, because of the fact that it either runs off the frozen surface of the ground or is dissipated into the air by the warm chinook winds.

The following explanation will make the graph clear. A heavy line has been drawn through the centre of the graph and marked 'zero,' and the columns above this line show the total amount of precipitation which took place during the months of April and May, June and July, and as shown in the small key above, the amounts falling during the three periods of April and May, June and July are distinguished by the solid and empty spaces in the columns. Similarly applied, the columns below the zero line, show the precipitation which took place during the months of August, September and October. The height of the columns above or below the line show, in all cases, the depth of precipitation in inches.

It has also been accepted as the truth that for any particular year, only the precipitation which falls in April and May, June and July, is useful to the plant growth to that particular year, and that the precipitation which falls in August, September and October of any year does not do any good to the crops of that year, but is stored up in the ground (on any field that is properly cultivated) for the use of the next year's crop.

No definite figures are available for the year 1884 and these columns have therefore been dotted in to show the approximate rainfall, but it may be stated that in the old times, 1884 was looked upon as a very wet year.

The two dotted lines above and below the zero line represent a useful precipitation of 6½ inches prior to July 31 and 3½ inches in the fall of the year, it being the opinion that when the columns of useful precipitation fall inside of these dotted lines that irrigation is necessary for the growth of crops in the Calgary district.

By studying the graph and observing these dotted lines it is very easy to pick out the 'old dry years' extending as shown by the graph from 1884 up to 1896, and it was during these years that so many hardships were suffered by the old time farmers who were endeavouring to farm the land, by what was thought to be in those days, good methods of dry farming.

SCHEDULE OF BENCH MARKS ESTABLISHED DURING THE SEASON 1912.

Location.	Elevation.	Remarks.
	Feet above sea level.	
Datum derived from C.P.R. levels at Moosejaw...		
At N.W. corner of Tugaske..........		
Sec., 13-22-3 3......	1968.62	Permanent Government. B.M.
At N.E. Corner Sec. 6-21-7-3..........	2083 08	" " "
At N.E. Corner Sec. 14-21-7-3....................	2011.74	" " "
At N.E. Corner Sec. 35-20-6-3	1983.82	" " "
At E¼ Corner Sec. 36-19-5-3......	1961 14	" " "
At N.E. Corner Sec. 26-19-5-3....................	1980.73	" " "
At E¼ Corner Sec. 24-19-4-3............	1985.59	" " "
At N.E. Corner Sec. 25-19-3-3............	1986.07	" " "
At N E. Corner Sec. 23-17-1-3....................	1954.27	" " "
At E¼ Corner Sec. 1-16-27-2......................	1939.02	" " "
At N.E. Corner Sec. 24-13-24-2.......	1919.78	" " "
At N.E. Corner Sec. 36-10-19-2	1904.57	On Section Post.
At N½ Corner Sec. 34-11-19-2	1879.24	Permanent Government. B.M.
At N.E. Corner Sec. 36-16-20-2	1881.99	" " "
Datum derived from Dominion Government B.M. No. 90..............................		
Set at N.E, Corner Sec. 36-1-25-4	3937.84	
Sill headgate A.R. & 1 Canal............	3853.80	Kimball, Alberta.
At N.E. Corner Sec. 9-1-25-4.....................	4018.82	Top Iron Post.
At E¼ Corner Sec. 8-1-25-4................. ...	4054.28	Permanent Government. B.M.
At 275 East of N.E. Corner Sec. 10-1-26-4........	4332.66	" " "
At E¼ Corner Sec. 6-2-26-4.......................	4394.36	" " "
At 1912 South of E¼ Corner Sec. 12-2-28-4. . .	4396 87	" " "
At N.E. Corner Sec. 5-2-27-4	4372.65	" " "
At Cable Station, Belly river..		" " "
Wests ranch, N.E. ¼ Sec. 5-2-28-4	4356.74	" " "
At Cable Station Waterton river, N.E. ¼ Sec. 8-2-29-4	4162.56	" " "
Wateron Lakes......................	4158.87	High Water Mark.

COST OF SMALL IRRIGATION SCHEMES.

The question is very often asked as a matter of interest—'What is the usual cost of the works in constructing small irrigation schemes?' To get the average cost, in this connection, of all the small irrigation schemes would entail a considerable amount of work, and lack of time has made it impossible to get all these details.

The following table, however, shows twenty schemes picked absolutely at random out of the office register, as applied for under the land sale regulations approved by an Order in Council dated the 9th day of November, 1910, and amended by an Order in Council dated 25th of November, 1912.

The headings on this table make it quite easily understood, the idea having been to show the total amount expended by the applicant, the total area of land bought, and the irrigable area bought. The cost has been worked out per acre of the total area bought, but as a column has been inserted showing a percentage of irrigable area, this can easily be reduced to the cost per irrigable acre:

File.	NAME.	Tp. Rg. Mer.	Total cost of works.	Area brought.	Irrig. Area	Per cent. of Irrig. Area.	Cost per acre. Total Area.	
			$	Ac.	Ac.	%	$	
1136	D. Tenaile	8-22-3	375	160	100	63	2.35	
1162	W. Small	9-27-3	405	160	150	94	2.53	
1047	Muir & Frantzon	5-2 -4	1147	480	260	54	2.36	
1229	J. A. English	7-3 -4	1391	640	485	75	2.17	
1287	H. Parker	9-20-3	164	160	90	57	1.03	
1183	J. Garissers	6-23-3	442	160	80	50	2.76	
1297	W. B. Gregg	3-29-3	1289	480	252·5	53	2.68	
1306	J. A. Burt	12-2 -5	205	160	120	75	1.28	
1369	McGarth & Morgan	8-27-3	128	160	90	57	.80	
1411	K. Sinclair	10-19 3	465	160	86·5	54	2.90	
1404	H. E. & A. A. Dimmock	11-21-3	973	640	281·4	60	1 52	
1353	W. Moore	12 20-3	1244	640	355	55	1.94	
1468	Park Hill & Forster	23-13-4	5435	1440	774·5	54	3.77	Pumping.
1431	T. A. Drury	10-26-3	182	160	80	50	1.14	
1407	W. R. Holding	12-20-3	1223	640	609	95	1.91	
1415	J. W. Lumley	1-2 -4	711	160	160	100	4.44	
1540	Gordon Ironside & Co	14 30-4	175	160	80	50	1.09	
510	O. Baudry	17-4 -5	424	560	354	63	.75	
1473	J. E. Jones	3-30-4	184	160	80	50	1.15	
1589	A. Peake	26-17-4	3628	238	198	83	15.24	Pumping.
705	T. A. Drury	6-25-4	427	160	120	75	2.67	
					Average	65%	$2.69	

REPORT ON SOUTH SASKATCHEWAN DIVERSION PROJECT BY R. J. BURLEY.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Calgary, Alta.

SIR,—I have the honour to submit herewith my report on the South Saskatchewan Diversion Project.

PREVIOUS WORK AND REPORTS ON PROJECT.

In the spring of 1911 Mr. T. Aird Murray, C.E., Consulting Engineer for the Bureau of Health, Province of Saskatchewan, reporting on the available sources of water supply for the Moosejaw and Regina districts, pointed out that the local available supply depended on (a) storage of creek water freshets and, (b), underground water collected by means of wells sunk into the sand and gravel at shallow depths beneath the soil covering; that the first mentioned supply was inadequate and very liable to contamination by organic growths and pollution from farm yards, &c.; that the last mentioned supply was difficult to estimate, but that general experience of such supplies pointed to a maximum limited amount insufficient for the growth of a city of 20,000 inhabitants, while as a rule they would not produce water for a population of over 2,000; that the then per capita supply in Moosejaw was about 17 gallons per day, and that the cities must be able to count on at least 30 gallons per capita per diem; that in his opinion it would be impossible to obtain an adequate

supply of water for a population of 50,000 in Regina and Moosejaw from such sources, while the towns along the Pasqua branch of the Canadian Pacific railway are in the same position. He further suggested that the only apparent available water supply in unlimited quantities is the South Saskatchewan river, and that he was forced to the conclusion that any such scheme must depend either upon pumping water over or tunneling through the height of land and carrying it to Buffalo lake in a pipe 6 feet in diameter. In conclusion Mr. Murray pointed out that the growth and development of the district is dependent upon an abundant supply of good water, and that no community can grow beyond its water supply; he advised that the Dominion Government be requested to reserve 100,000,000 gallons of water per day from the South Saskatchewan river and that field surveys be undertaken at once to obtain the necessary data to determine the best and most efficient method of dealing with the scheme.

In this report it will be noted that Mr. Murray arrived at the conclusion that the South Saskatchewan river must be the ultimate source of water supply for the Regina and Moosejaw districts, and that he recommends the construction of a pipe line along the Qu'Appelle valley, allowing each town to pump its supply to the necessary elevation after its delivery to Buffalo lake. This phase of the question will be taken up later in this report, as will the rough estimate of cost given in his report.

Another interesting point in connection with the report is the very low per capita consumption at that time in Moosejaw and the low figures used in estimating the future requirements, as Regina is estimated to have already passed the 50,000 mark, while Moosejaw's population is estimated at between 28,000 and 30,000. With regard to the per capita consumption of 50 gallons per diem, assumed in the last part of his report, it should be noted that in 29 cities in the United States the supply varies from 41 gallons per capita per diem in Fall River, Mass. (population 106,600), to 324 gallons per capita per diem in Buffalo, N.Y., with a population of 401,000. The average consumption in these cities is 122.6 gallons per capita per diem, while the average daily rate in the city of Toronto, with a population of 290,000, is 118 gallons.

Mr. John R. Freeman, C.E., in his report on the New York city water supply in 1899, estimated that 31 to 56 gallons were used, 10 gallons unavoidably wasted, and 50 to 75 avoidably wasted, but it must be noted that the practice on this continent generally is towards a liberal use of water, and at present there is nothing to justify the assumption that this practice will be discontinued in the near future. Possibly in estimating for future supplies it may be assumed that the practice on this continent will approach the present practice in Europe, viz., 30 to 40 gallons per capita per diem, within say the next fifty or seventy-five years, more especially when strictly metered services are put in force and leakages and other wastes properly taken care of, but up to the present there is no indication that such will be the case. It is probable, however, that the consumption will always be somewhat higher here on account of the danger from frost during the winter season and because the dry summers necessitate the liberal use of water on lawns, gardens, &c. In England and on the continent of Europe the winters are not nearly so severe and during the summer season the precipitation is such as to preclude the necessity for the application of water artificially.

In May and June, 1911, Mr. W. J. Francis, consulting engineer, of Montreal, made a reconnaissance of the whole district surrounding Moosejaw with a view to locating some body of water sufficiently large to assure that city permanent supply and, in his report, after examining all the possible sources and summing up the advantages and disadvantages of each, he arrived at the conclusion that the South Saskatchewan river offered the only satisfactory solution to the problem and that it must ultimately be the source from which this district should draw its water supply for domestic purposes.

In conclusion Mr. Francis was very strongly of opinion that when the southern half of the province of Saskatchewan will have become densely populated, the South Saskatchewan river will be found to be the only source of water supply for domestic purposes and he gave many reasons for this conclusion. He further believed that the best method of obtaining such a supply would be by means of a concrete dam in township 21, range 7, west of 3rd meridian, to give poundage and to furnish hydraulic power for pumping to a filter, thence to a reservoir on the height of land and from there through a gravity pipe line along the valley of Thunder creek, recommending that a general topographical survey be made along this valley.

The Dominion government realizing the importance of this question to the people of the district and the urgent necessity for development work, decided to take the matter up and to send a party into the field to develop critical elevations in the neighbourhood of the proposed intake.

In accordance with this decision Mr. B. Russell was instructed in the fall of 1911 to take certain levels and to make a reconnaissance of the river valley and banks between the 'Elbow' and the valley of Thunder creek, developing such levels as would indicate where the lowest points in the height of land would be found.

Then, in March, 1912, the Commissioner of Irrigation, after briefly summarizing the work of Mr. J. S. Dennis in 1894, 1895 and 1896 reported upon the level work and reconnaissance done by this party the previous season, showing that this work clearly demonstrated the undesirability from several standpoints of the scheme for diverting water over the Aiktow creek divide and down the Qu'Appelle river.

In this report a scheme was worked out involving a dam and pumping plant on the river with a reinforced concrete pipe line of varying capacity along the west side of Thunder Creek valley, around the head of Moosejaw creek and thence to Regina.

This pretty well summarizes the previous work on the scheme and it is interesting to note that all the reports agree that, ultimately, the towns and cities in the Moosejaw and Regina districts, if not the whole of southern Saskatchewan, must look to the Saskatchewan river for their future water supply; also, that the development of water power for pumping the water supply over the height of land and the gravitation of this water to the points of consumption will be desirable features in any scheme and further, that a pipe line along the higher land will be a most desirable feature. The estimates of cost are only approximations owing to the meagre data at hand and therefore vary considerably.

All the reports agree that the ultimate development of this district depends largely on the nature and permanency of its water supply, and that no community can possibly develop beyond the size warranted by this factor.

PRESENT WATER SUPPLY FOR THE DISTRICT.

Throughout the southern portion of the Province of Saskatchewan the cities and towns have been in a very poor position as regards water supply ever since the country became settled up and the situation is becoming more acute each year as the urban population increases. The sources at present used may be subdivided into (1) local surface supplies from run-off, (2) springs, (3) sub-surface supplies.

Under the first heading comes the water supply system applied for by Weyburn, Saskatchewan, where it was proposed to bring water from Shallow lake through a branch of the Souris river to a pumping station where it will be raised to the necessary pressure. This scheme has, however, since been abandoned in favour of a storage scheme in Beaver Dam creek and the Souris river. At this point a supplementary supply is obtained from shallow wells sunk in the gravel, but the water thus obtained has been found quite insufficient to supply the demands of the town.

Moosejaw now obtains water from three sources, viz.: Sandy creek, Snowdy's springs and Moosejaw creek. The water from the last named source of supply is used for fire protection purposes only and the Snowdy's springs supply has proven

entirely inadequate for the needs of the city for some years past. The new system for Sandy creek was only completed last winter and it is estimated that it will supply a population of 20,000 people with 50 gallons per capita per diem and, with the added flow of Snowdy's springs, there should be enough water for twenty-five thousand. This estimate was based on measurements showing a flow of about two cubic feet per second in May, 1911, but there is some doubt as to whether this flow will be maintained throughout the year.

Regina is supplied partly by the Boggy Creek springs and partly by sub-surface springs and wells. As noted above such sources of water supply are usually considered inadequate for any large population and it is only a question of a few years before other provision must be made to supply this city.

Smaller towns along the Portal and Arcola branches of the Canadian Pacific railway are utilizing small springs or surface supplies, which are, however, in all cases inadequate to supply any large increases in population, while along the railway lines under construction, many towns and villages are springing up each year.

The railways are finding extreme difficulty in obtaining a plentiful supply of water suitable for use in their engines, and each year the increase in traffic makes a heavier draught on the present supply. Further, in the majority of cases the water is of poor quality and continually causes trouble with the boilers, more especially in the winter.

The lines being constructed will naturally increase the traffic, creating a still greater demand for water; therefore, some new source of supply must be provided, and it is apparent that the companies are facing a problem which is becoming more difficult to deal with each year.

From a careful consideration of the foregoing, it is evident that the South Saskatchewan river must ultimately become the source of supply for the cities and towns of Southern Saskatchewan if this district is to attain the importance and population to which its natural advantages entitle it. The following points will therefore become apparent, that:

(1) The present low per capita consumption is not likely to be maintained, as it has been found in practically all American cities that the tendency is for a very large consumption of water, and at present there is no reason to suppose that this district will be an exception to the practice when the population increases and an ample supply of water can be obtained.

(2) Any scheme contemplating the use of the natural drainage channels would prove unsatisfactory owing to the nature of the stream beds and the liability of pollution from surface drainage.

(3) A gravity pipe line of large capacity from which each community draws its supply by means of smaller pipes apparently offers the best solution of the problem, as, in such construction, the source of supply is brought within easy reach of the smaller towns and villages, so that they can utilize the water at a cost within their available means.

(4) It appears to be the concensus of opinion that development of power by means of a dam across the river affords the most satisfactory solution of the problem of the high lift necessary to divert water over the height of land.

(5) The three great railway companies are vitally interested in the question and should welcome any improvement in conditions. They are confronted with large increases in traffic which will be even greater as the branch lines are extended and the country becomes more closely settled, for which increase the present water supply is quite inadequate.

FIELD WORK.

Organization of parties.—After it had been decided in July, 1912, to undertake a preliminary survey of this scheme, and pursuant to your decision that only one

large party would be placed in the field until the work on the Belly river diversion canal had been completed, Mr. T. M. Montague, B.Sc., was placed in charge of a party of twelve men, the necessary equipment was purchased and shipped to Tugaske, and from this point field operations were commenced on July 23.

Previous to this date Mr. Montague had made a short reconnaissance of the district around Central Butte and Marklee, dealt with in his report, and Mr. Gleeson was sent to Swift Current with a rodman to carry levels from the Canadian Pacific railway bench mark there, to the water level of the South Saskatchewan river, north of that town.

A permanent iron bench mark was established at Tugaske and referred to the datum of the Canadian Pacific railway profile. From it a line of levels was carried westward to the water level of the river in section 33, township 22, range 7, west of the 3rd meridian, and levels were then run southward along the road allowance three miles east of the range line between ranges 7 and 8, west of the 3rd meridian, to a point in the Thunder Creek valley where the preliminary location was commenced.

Location of B. M.	Bench Mark	Tugaske Datum.	Sea Level Datum.
Tugaske	D.G.B.M.	1945.87	1968.62
N. E. Cor. 6-21-7-3	"	2060.33	2083.08
N. E. Cor. 14-21-7-3	"	1988.99	2011.74
N. E. Cor. 35-20-6-3	"	1961 07	1983.82
Marked R.L. xxvi E. ¼ Cor. 36-19-5-3	"	1938.39	1961.14
N. E. Cor. 26-19-5-3	"	1957.98	1980.73
E. ¼ Cor. 24-19-4-3	"	1962 84	1985.59
N. E. Cor. 25-19-3-3	"	1963.32	1986.07
C.P.R. Main Line on north side of right of way 1½ miles east of Mortlach	"	1931.52	1954.27
E. ¼ Cor. 1-16-27-2	"	1916.27	1939 02
N. E. Cor. 24-13-24-2	"	1897.03	1919.78
N. E. Cor. 36-10-19-2	Iron section pin.	1881.82	1904.57
N. ¼ Cor. 34-11-19-2	D.G.B.M.	1876.49	1899.24
N. E. Cor. 36-16-20-2	"	1859 24	1881.99
Regina	Base of rail front of C.P. R. station.	1865.76	1888.51
Base of Rail Milestone		1883.95	1906.70

While the party was carrying through these levels, a reconnaissance was made of the river valley in townships 21, 22 and 23, range 7, west of the 3rd meridian, from which it was concluded that the best outlet for the line would be in township 21, range 7, and Mr. Montague was accordingly instructed that the line be commenced at this point. The reasons for choosing this line are as follows, viz.:—

Upon examining the district to the east of the river, it was found that a ridge some fifty to seventy-five feet in height extends parallel to the river banks and five to six miles distant from them clear across that portion examined, and only one break could be found in it. This pass occurs at the junction of the ridge with the Vermilion hills in section 22-21-7-3, and forms the head of Thunder Creek valley.

Owing to the high cost per foot of pressure pipe, it was evident that an important point in the location would be the shortening of this pipe line as much as possible. It was therefore decided to abandon the six or seven mile lift necessary to carry the water to the height of land from the dam site surveyed by Mr. Russell in 1911, and by moving the intake up to a point near the mouth of Shellstone creek in section 18-21-7-3, and utilizing the pass above referred to, it was found possible to reduce this pressure line length to some thirty-seven hundred feet, thus making a saving of several miles of expensive pressure pipe, and also shortening the gravity line. A

further point to be considered is the possibility of utilizing the Shellstone creek valley as a settling basin, and this will be dealt with later in the report. Owing to the general topography of the district, it will be found a difficult matter to greatly alter the present location of the line at the upper end unless a new line altogether is found feasible further down the river.

The preliminary line was located from the river bank to a point some one and one-half miles east of Mortlach by Mr. Montague, from which point it was carried on into Regina by Mr. Russell. The details of the work of the parties are dealt with in the reports of Messrs. Montague and Russell, and as these are included in this report this point need not be enlarged upon here.

Reconnaissance work.—During the past season the section along the river and lying between the Vermilion hills, the Outlook branch and the main line of the Canadian Pacific railway was thoroughly covered in order to obtain an idea of the best part of this district in which to locate a line, and it was found that, in general, the country is very broken by ranges of hills and deep coulees, especially along the southwest side of Thunder valley and along the river between Shellstone creek and the mouth of Swift Current creek. The whole district is comparatively poorly supplied with water, and fuel is difficult to obtain. In selecting camping places it was often found that water was not only deficient in quantity but poor in quality, more especially along the Thunder Creek valley, making this a difficult district in which to survey.

The roads, generally, are poor, more especially in directions paralleling the river valley, or the Thunder creek valley, and much difficulty was experienced at times from this condition, aggravated as it was by the heavy rains during the latter part of August and September.

The district lying between Thunder valley and the Outlook branch is thickly settled, and a large proportion of the land is under cultivation. On the other side of the valley, however, the settlement is sparse and, in the majority of cases, the land has only been taken up recently, so that only a small proportion of it is cultivated, except in the vicinity of Mortlach. Along the river valley there are a few ranches, but, in general, it is practically unsettled, although the bench above it, west of range 9, is very thickly settled and a great deal of the land is cultivated.

The South Saskatchewan river between Shellstone creek and township 23, runs between banks from 250 to 300 feet high, and for the greater part of this distance the banks are quite steep on the east side with some flats of ½ to 1 mile in width on the west side. The width of the water surface is between 1,600 and 2,400 feet, and the bed is composed of a fine quicksand with outcroppings of blue clay in places. Sand bars in the river bed are of very frequent occurrence, and are likely to shift during high water periods. For some three miles above Riverside and for about one-half mile below, the east bank near the river is composed of drifting sand dunes, in some places 60 to 100 feet in height, and practically devoid of vegetation. Lower down at a point in section 33-22-7-3 this sand disappears and the banks are very steep, composed of a yellow clay and showing a good deal of stone, in the shape of gravel and boulders, mixed in the clay. The vegetation is sparse all along this stretch of river until a point half-way up the banks is reached. In general it may be said that the west side of the river differs greatly from this, as there are several large flats along it and the vegetation indicates that the soil is much better. At a few places, which will be described more fully later in this report, there are high, steep banks on both sides of the river which form fair dam sites.

Above the sand dunes mentioned, the east bank of the river is deeply cut by coulees, and rises more or less in ledges. The soil is generally of a very poor quality, being an alkaline alluvial clay with a quantity of stone and some gypsum, corresponding in many ways with the bad lands found along Milk river. Practically no deposits

of sand or gravel were found suitable for concrete, with the exception of one small outcropping of a coarse red sand in section 30-21-7-3, which might prove to be of value if excavations were carried out, and what appears to be a gravel bar in the river itself a short distance below the mouth of Shellstone creek. At the time the reconnaissance was made, the river was too high to make any satisfactory examination, and it could not be determined just how far this bar extended across the stream. In general it may be said that the river valley up to the fifty foot contour is between three thousand and five thousand feet wide, with all the tillable flats on the west side and practically no land of any agricultural value on the east side.

Shellstone Creek Valley.—Shellstone Creek valley extends as a wide, comparatively shallow depression for some six or eight miles through townships 22 and 21, range 7, west of the 3rd meridian until it is joined by a spring creek near the east boundary of section 22-21-7-3. About this point the slope of the creek valley is comparatively slight and in it are a large number of slough beds, showing that the run-off is small. Below, the valley falls rapidly toward the river and, at the mouth, forms a flat between three-quarters of a mile and one mile wide, grown up with willows, buffalo-berry trees and some poplar. The river banks above and below this point rise abruptly and form a good location for the intake of a pipe line.

River Valley between Shellstone Creek and Log Valley Ferry.—Just above the mouth of Shellstone creek the river passes out of the Vermilion hills and turns north. The banks rise very abruptly, in benches, on the southeast side above bottom flats one-quarter to one half mile in width, and are much higher than farther down the stream, owing to the fact that the river cuts through the comparatively high range of hills known as the Missouri Coteau, making the valley probably between five and six hundred feet deep. At Log Valley ferry, the hills approach the river very closely on the north side, while there are narrow flats on the south side some forty feet above the river level.

The flats along this stretch of river are traversed at frequent intervals by small alkaline spring creeks, and the land appears to be of very poor quality. No sand was seen excepting in the river bed itself, but a bank was noted at the top of the hill in section 12-21-8-3 which appeared to contain a large amount of gravel suitable for concrete work. The river along this stretch is very wide and the current is sluggish, while sand bars and sandy islands are very frequent.

For some twenty miles above Log Valley ferry it was found impossible to travel along the river on account of the very deep, precipitous ravines and spring creeks running back from three to six miles, making it necessary to drive out on the points between these and walk down the banks at intervals. Here the valley is probably some three to eight miles wide at the top, and 600 feet to 800 feet deep, the land being of no value from an agricultural standpoint, and of very little value for any other purpose.

The next point at which the river could be reached by road was on the east range line of Township 20, Range 11, West of the 3rd meridian, and above this for some seven or eight miles there are some small flats averaging about $\frac{1}{4}$ to $\frac{1}{2}$ mile in width on either side of the river, fit for cultivation. The main banks are very rough and devoid of vegetation, showing the same formation as lower down, the bed of the river being similar to that near Log Valley.

A short distance west of the west boundary of Range 11, the character of the river bed changes, the banks becoming less precipitious with a better quality of soil. The water width is reduced to approximately one third, and the fall increases from some 1.3 to about 2.5 feet per mile. Here the sand bars, characteristic of the stream lower down, practically disappear, and the river bed apparently is composed mainly of clay and gravel with large boulders. Every half-mile or so there are small rapids, having

a fall of about one foot in three hundred feet. Near the mouth of Swift Current creek there is a flat from one-half to one mile wide extending westward some three miles on the south side of the river. Above this point the banks close in, the land becoming poorer in quality, although there are some flats containing very good soil.

To sum up it may be said that, from Saskatchewan Landing to the east boundary of Range 12, the river valley is comparatively narrow, with banks ranging from 250 to 350 feet in height, the slopes generally being fairly gentle, with occasional cultivable flats at an elevation of from twenty to forty feet above water level. The river bed itself is narrow, practically free from sand bars, and composed of a gravelly clay with occasional large boulders. From this point to the Snake Bite coulee ferry, on the east boundary of Township 20, Range 11, the banks are higher, the land of a poorer quality, and the valley much wider. The river channel widens greatly and the character of the bed changes to a sandy formation with frequent bars and islands. The fall is considerably reduced, and the current becomes correspondingly slower. Flats appear quite frequently at elevations of between ten and fifty feet above water level, and appear to contain good soil.

Below this point, through the Missouri Coteau, the valley is wide and deep, with practically no flats, and the soil is of a poor character as far down as the Log Valley ferry. From here to Riverside the valley is similar to that above the mouth of Swift Current creek, except that the river channel still has a wide, sandy bed with a small slope and a sluggish current.

Extent of settlement.—There are very few ranches in the river valley itself below the two hundred feet contour, and comparatively little valuable land would be affected by a dam thirty-five or forty feet in height, as it is doubtful if such a low dam would injuriously affect any but those situated directly on the river bank. So far as could be learned, the following comprise practically all the places in the river valley which would possibly be affected by the erection of a dam in the vicinity of Bryceton or Riverside:—

The construction of a dam on site 'A' would flood the ferryman's house on the east side of the river and the ranch on the west side, near the north boundary of Township 22, Range 7, West of the 3rd meridian. At Riverside, Section 32-22-7-3, a homestead and a few acres of very poor land on the east side of the river would be similarly affected.

Along the west side of the river, between Section 18-22-7-3 and Section 25-21-8-3, there are large flats comprising the ranches of Messrs. Jones and J. E. Belhumeur which would be affected by a dam on either site 'A' or 'B.'

At Log Valley, Section 3-21-8-3, there are small places on either side of the river which would be affected by a dam in the vicinity of Shellstone creek (site 'C'), but not greatly by a dam lower down the stream. The lower land of Mr. Henry Richardson in Sections 33 and 34, Township 20, Range 8, West of the 3rd meridian, is in a similar position.

Above this, up to the Snake Bite coulee, there is only one ranch along the river as far as could be learned, which could not be conveniently reached.

At the Snake Bite coulee ferry, on the east boundary of Township 20, Range 11, West of the 3rd meridian, there are two small farms, one at either end of the cable, and a larger one on the north side of the river some one and a half miles farther up. These would probably be unaffected by the low lift proposed. Above this point and below Saskatchewan Landing there are several ranches. It is unlikely, however, that water would be backed up as far.

THUNDER CREEK VALLEY.

Thunder creek valley, beginning in Sections 1 and 12, Township 21, Range 8, West of the 3rd meridian, as a wide, shallow depression, with a low divide about one

mile east of the top of the river bank, extends in an easterly direction for ten or twelve miles, with but a slight slope. A chain of slough beds exists along the lowest part, connected by a shallow, indistinct channel. The soil is a heavy, alkaline clay, hard when dry, and sticky when wet, making excavation a difficult matter except during dry weather. The bank on the north side is, at first, very low, gradually increasing in height until along the south part of Township 21, Range 6, West of the 3rd meridian it becomes a steep, rough slope about one hundred feet high, cut at frequent intervals by coulees. The south bank coincides with the main slope of the Vermilion hills as far east as Section 5, Township 21, Range 6, West of the 3rd meridian, and from there on it is similar to the north bank, gradually increasing in height and deeply cut by short coulees and spring creeks.

At the north boundary of Township 20, Range 6, West of the 3rd meridian, the valley turns south, widens out greatly and changes somewhat in character. Just below this point there is a small lake some three and a half miles in length, with a sandy bottom and well defined banks, covered with gravel and boulders. Several small springs and spring creeks discharge into this lake from the west side, and there is a shallow outlet at the south end which provides for the overflow and is the head of Thunder creek.

To the west of this lake, above the valley, there is a strip of comparatively flat land some three miles in width, lying between the valley and the slope of the Vermilion hills, which is now settled up and is fast being put under cultivation, while practically all the land on the east side is well cultivated. Below this lake to within a short distance of the second lake in the northwest corner of Township 19, Range 5, West of the 3rd meridian, the valley is wide and has a small slope, being for the most part good agricultural land. Above the second lake for some distance the banks of the valley become steeper, are covered with rocks, more frequently cut through by coulees, and gradually become higher. The district to the south of the valley is sparsely settled and shows a good deal of surface stone, while on the north side the settlement is comparatively dense and the soil is good. This lake is of an alkaline nature, and is fed by a few small springs on the south side. The bottom is a black alkaline mud, and is very soft, although appearances indicate that this formation does not extend to any great depth.

From the second to the third lake in Townships 19 and 20, Range 4, West of the 3rd meridian, the soil in the bed of the valley contains considerable alkali, the banks are high (between 200 and 300 feet) and steep, while short, deep coulees are of frequent occurrence. Along this part of the valley the continuation of the Vermilion hills is cut through, with the resulting deep valley and steep banks. The lake bed itself is usually dry, with a heavy growth of marsh grasses, and is composed of a black, vegetable loam, somewhat alkaline in nature. Considerable loose rock is evident along the valley banks, and steep gradients are the rule.

Below this lake the valley gradually becomes shallower, and widens as it passes out of the hills in Section 20, Township 19, Range 3, West 3rd meridian, and from this point it may all be said to be tillable with the exception of the alkaline sloughs which appear both in the valley proper and in the district to the south.

A second valley breaking off about the centre of Township 19, Range 3, West 3rd meridian, extending in a southeasterly direction toward Mortlach, contains several large alkaline sloughs, and at first sight it appears to offer a shorter location for the pipe line than does the line along Thunder creek valley proper, but on running through it was found that the cut necessary would be between thirty and thirty-five feet for some miles, and this trial line was abandoned in favor of the line along the creek valley.

In that portion of the country to the north and east of Mortlach, numerous small sand hills appear, extending on both sides of the main line of the Canadian Pacific railway for some miles east.

In review it may be stated that, for the most part, the bed of the valley is composed of a heavy clay, strongly alkaline in places, and of such a nature as to render excavation somewhat difficult in wet seasons. The lakes occurring in the lower portion of the valley become less desirable as reservoir sites and the banks of the valley on the north side are steep and stony, particularly along the lake beds. Excavation may be found difficult at these points owing to the amount of loose rock, but in other respects the valley offers a very good location for a gravity line, owing to the fact that there is a steady rise to the west and south, rendering long siphons or pressure pipes unnecessary. Short ones, on account of alignment, are often desirable and have been used in the location.

As the valley is still practically unsettled, with little cultivated land, the expense of acquiring right-of-way will be small, and little difficuty will be experienced in obtaining a hundred foot or even wider strip all the way along the location.

DAM SITES.

In the reconnaissance of the river valley the principal object in view was the selection of sites suitable for the erection of a dam, and two methods of procedure were considered.

Under the first method the dam would be erected near the proposed pipe intake and the water pumped from the backwater formed by the dam, while, under the second, the dam would be erected at the narrows some distance above the intake and the water pumped direct from the river. From a reconnaissance survey and without soundings and borings of the river bottom, it is impossible to state at the present time which of these schemes will prove the more practicable. However a few of the advantages and disadvantages of each will be pointed out.

If the dam be constructed near the proposed intake between the mouth of Shellstone creek and section 10, township 23, range 7, west 3rd meridian, the height of lift will be reduced between 25 and 40 feet, the backwater formed by the dam will act as a settling basin and the pump intakes will always be able to draw in a good head of water. In this case the greater part of the silt will settle in the long reach of backwater and the water will not only be more easily filtered, but the destructive action of sand on the pumps will be more or less obviated. On the other hand the construction of a dam in this portion of the river will necessitate a large expenditure to erect a safe structure on a sand foundation, and further, the width of the spillway would probably be 3,200 to 3,600 feet, along the crest.

By building the dam above the narrows, it would be possible to obtain a firmer foundation, a crest length of 1,000 to 1,500 feet and a much cheaper substructure than lower down, while sand and rock for concrete could probably be more easily obtained. Such construction, however, would necessitate a total lift of 304 feet, a long transmission line and the construction of larger settling basins, resulting in a poor intake and damage to pumps through the action of sand on the valves or rotors.

With the information at present on hand, it would appear that the former method is preferable but, before deciding finally upon the best location, comparative estimates should be made after borings have been taken in the river bottom.

Having in view the first method, three sites were selected for development last summer, as follows:—

(*a*) A point about 2½ miles north of the north ferry at Riverside, in sections 15 and 16, township 23, range 7, west 3rd meridian. This location appears from an inspection to be the best along the lower stretch of river. The banks are of yellow clay, interspersed with boulders, rising steeply from the river, and the width of the

water surface is here less than at any other points noted below range 12. It is possible, however, that the clay bed pitches sharply, as do the banks, and will be found beneath a considerable depth of quicksand, as at Outlook.

(*b*) A point about four miles north of the mouth of Shellstone creek, in sections 5 and 6, township 22, range 7, west 3rd meridian. The cross-section here is somewhat wider than the one mentioned above, and the banks do not rise so sharply above the river. The water surface is about 2,000 feet wide at high water, with one small island and several sandbars showing immediately below it. The west bank is a steep, grassy slope, apparently of clay loam, with little stone, while the east bank is a cut bank composed of clay with some stone, the hill above this sloping more gradually for some 400 feet, and then rising in wide ledges, cut through by coulees.

(*c*) A point about one-half mile below the mouth of Shellstone creek in section 19, township 21, range 7, 3rd meridian. This site was chosen by Mr Jennings and the writer is not familiar with the exact location. However, the river along this stretch is wide, with frequent sandbars and sandy islands, and the west bank as a general rule is low. On the east side the banks are steep, composed of a grey, alluvial clay and deeply cut by coulees. The bed of the stream shows, in places, outcroppings of blue clay along the margin, and gravel bars appear to extend, at least partially, across the stream at a few points, indicating a possibility of a shallow sand covering over clay.

(*d*) At some point to be chosen between Saskatchewan Landing and the west boundary of range 12. A dam at this point would be erected under quite different conditions to one lower down, as the bed here is apparently a solid, boulder clay with occasional pockets of sand or mud. The width is not more than one-third of the width lower down, so there is little doubt that the cost of construction would be much lower in relation to the dam and even though the increased height of lift would necessitate a higher dam, it is probable this would be compensated for by the shallower foundation.

On the other hand the cost of construction of a transmission line, transformer stations, increased length and thickness of the pressure pipe would be added to this estimate, which, together with the further disadvantage of being without a settling basin in the stream or a good intake, would probably prove to more than offset any advantages gained on account of lower cost of construction. As stated previously, however, until borings have been taken on both sites and dam designs worked out, it is impossible to compare the two methods intelligently.

ALTERNATIVE LOCATIONS FOR PIPE LINE.

Considering the known elevations in this district, it is evident that there are several possible locations for a pipe line and, while the one chosen for partial development last season was considered the best, it is undoubtedly true that, at present, there is not sufficient information available to determine this point absolutely. Assuming that the fall chosen, 1 in 10,000, is the lowest that could be used advantageously, it will be seen from the elevations on the accompanying maps that water cannot be taken out much below the Elbow and gravitated to Regina and, owing to the largely increased distance, it would not be practicable to take it out much above the head of Thunder valley. With these as the controlling factors, there still remain three distinct possibilities, viz.:

1. The line developed, along the west side of Thunder valley and Moosejaw creek, crossing on the southern height of land and carrying the water in a grade pipe practically corresponding to a lined canal.

2. A line leaving the river south of Aiktow creek and following in a southeasterly direction along the south bank of the Qu'Appelle river to Regina, supplying Moosejaw by a subsidiary line and the country to the south by a second subsidiary line out of Regina.

3. A pressure line direct to Regina from the closest point on the river, supplying Moosejaw by a subsidiary line.

In the first case there are to be considered the advantages of a first-class reservoir site, a large area of country within easy reach of the line, no difficult questions affecting construction and very little right of way to purchase, while along a considerable portion of the line, sand and gravel suitable for concrete is easily obtainable.

In carrying a line along the second location, a pipe could probably be carried on grade to a point east of Tuxford on the Outlook branch of the Canadian Pacific railway. From there, however, the indications are that a series of inverted siphons would be necessary to cross the numerous creeks flowing toward the Qu'Appelle river between Moosejaw and Regina, possibly introducing many engineering difficulties, and running through a thickly settled country where the cost of right-of-way would be considerable.

The third route, viz., a direct line, would require a shorter pipe of somewhat smaller diameter, but there is little doubt that any such direct line would run above the hydraulic grade line in many places, introducing siphon systems that would prove unsatisfactory even when provision was made at the apices to remove the collected air. Further, the lower parts of the system would doubtless be subjected to considerable pressure, and the cost would probably be almost as much as in the case of the less direct grade line pipe.

A fourth possibility is that of diverting the present line below the proposed reservoir, following along the north side of Thunder valley, crossing the Outlook branch south of Tuxford, then proceeding directly to Regina, and constructing smaller pipes to supply Moosejaw and the south country.

Of the outlined schemes, it would appear that the best, considering the various interests, is the one at present surveyed although, owing to lack of information, it is impossible to make comparisons of cost. This scheme takes the water in a large main along the heads of the numerous streams flowing through the dry district, making it possible for the supply to be tapped at a reasonable expense by the smaller towns. The alternative propositions render the cost out of the question for the lesser municipalities unless smaller mains be carried out as branches. In this connection it should be noted that, while the carrying capacity of the pipe decreases at a rate somewhat greater than the inverse of the square of its diameter, the cost decreases practically directly as the diameter, so that while a five-foot pipe would cost half as much as one of twice that diameter, the capacity thereof would be less than one-quarter.

RESERVOIRS.

In any system of water supply the provision of reservoirs is most important and, in a system such as this, they are a necessity for the successful economic operation of the scheme. Owing to the hourly fluctuation in the quantity of water used by any city, it is desirable to have a small reservoir, at least, to maintain the constant head and pressure necessary for satisfactory operation, and to act as a balance pool to provide for extraordinary demands made on the supply. In the consideration of this particular scheme, however, still another factor enters into the calculation. During the winter months the flow of the South Saskatchewan river drops to approximately ten per cent of the mean summer flow, and while the mean summer flow is much more than sufficient to pump the total quantity of water required, still, during some four or five months of the year a comparatively high dam would be required to maintain this supply. The construction of a large reservoir would overcome this difficulty and a sufficient volume of water could be pumped, in excess of that used, during the high-water months to provide for the low-water period. Furthermore, the exposure of the water to the action of the sunlight and air tends to destroy objectionable bacteria and, although the storage of water for lengthy periods induces the growth of algæ and similar plant growths, causing objectionable odour and colour, it is possible to

overcome this by means of suitable coagulants and filters, making the inclusion of a storage reservoir highly desirable from the standpoints of sanitation and economy in construction.

During last season's survey, these facts were kept in mind and several sites of some value for reservoir purposes were noted. It was further found that at many points Thunder valley could be utilized with varying degrees of desirability and cost.

The first site noted lies above that surveyed and appears to be highly suitable except for the fact that its elevation is too great to enable it to be utilized with the lift at present contemplated. The next site occurs in the first lake in the valley and was chosen as the most suitable site available. As it was developed it will be fully described. Lower down the valley there are several lakes and numerous points in the valley itself which would form good locations but, as the lower valley soil becomes more strongly saturated with alkali it was considered that this fact alone rendered other sites undesirable.

LAKE IN TOWNSHIP 20, RANGE 6, WEST OF THE 3RD MERIDIAN.

Thunder valley turns to the south at the north boundary of the above mentioned township, entering a wide, level flat containing a lake bed some four miles long and three-quarters of a mile wide with a sandy bed and rock covered banks some 8 to 10 feet in height. At present the bed is covered with an accumulation of decayed vegetation and the lake itself is thickly grown up with reeds, but the water appears to be fairly free from alkali and no indications were observed on the banks which would point to any amount of these salts being present. The banks of the valley are steep and high on either side and on the west there are a number of short coulees containing small springs, forming no doubt, the source of the lake supply. At the north end of the lake a small ridge divides it into two arms, forming an excellent location for the low earth fill necessary to keep the water from spreading too far into the valley.

The easterly arm of this lake can easily be cut off by means of an earth fill and will form a suitable reservoir for the scheme constructed on the smaller scale estimated in this report. As will be seen from the plans, this reservoir site is some 1,250 acres in area up to the 1,960 contour with an approximate capacity of 18,750 acre feet. The easterly arm contains 337·6 acres with a capacity of 2,913 acre feet.

In connection with this reservoir, a by-pass having the full capacity of the outlet pipe has been included, running around the west side of the lake in order that the supply need never be closed down, in case it is necessary to cut out the reservoir at any time. It has been also been planned to carry off the natural run-off by means of a small pipe running directly through, beneath the reservoir. This pipe need not be of large diameter, as there is a small drainage area above the lake and the evidence all points to a very small run-off, as the chain of sloughs along the lowest part of the valley have no defined channels connecting them. Dams have been provided for at either end of the lake with the idea of preventing the water spreading up the valley in a shallow pool, with the consequent evaporation and seepage losses and the increased danger of contamination. These dams are figured on as earth fills, riprapped if necessary.

The bed of the lake is sand, evidently underlaid with clay and having considerable decayed vegetable matter above the sand. Large patches of reeds grow all over the lake bed and it is evident that it must be cleaned by stripping or burning after it has been drained. Possibly the greater part of the peat could be burned off after the bed became well dried, but it is probable that the greater part of it must be stripped to a depth of one or two feet to remove the roots, &c., which might otherwise contaminate the water. On the other hand it is most likely that the deposits from the stored water will soon leave the bed in as bad shape as before, unless a settling basin is provided, even if the stripping be done, and it will be difficult to

provide suitable sluiceways to carry off this silt owing to the slight slope of the valley itself below the lake.

There are several spring creeks emptying into the lake on the west side and it is probable that some provision must be made to divert these owing to the liability of pollution from them, passing, as they do, through a district which will soon be closely settled.

INTAKE BASIN.

At the outlet of the pressure pipe, it will probably be better to provide an intake basin from which the gravity main can be supplied and which will act as a regulator of the discharge from the pressure pipe, thus maintaining an even flow in the gravity pipe to the reservoir. While this purpose would not demand a large reservoir, still, in view of the very finely divided material existent in the South Saskatchewan river water, it is doubtful whether the lighter components of the silt will settle out, even if the water is taken out immediately above the dam. It is also probable that a further settling basin will be required at the outlet of the pressure pipe. Thus, by the possible provision of a suitable location, two good purposes can be served with one basin.

As mentioned previously, the Shellstone Creek valley presents a good location for a basin of this description, one which could be constructed at a comparatively small cost. As this creek flows directly back into the river through a well defined channel, practically any desired depth and excellent facilities for sluicing out could be obtained, at small expense.

Settlement and the use of suitable coagulants at this point would ensure that the water flowing into the main reservoir would be free from silt and that the floor of this reservoir would seldom need cleaning, while the deposited silt and impurities could be easily disposed of by running the sludge back into the river.

POWER POSSIBILITIES.

Unfortunately the hydrographic data on the South Saskatchewan river only extend over two winter seasons, and it is impossible to state whether or not the records of these seasons show the lowest water, so that in estimating the power available from dams of different heights, a considerable excess has been allowed to provide a safe margin in the event of the flow of the river falling greatly below the quantity as shown by the records.

Hydrographs have been prepared and are included herein, showing the daily flow of the river at Medicine Hat and at Saskatoon and, based on these data, mass curves and pumping curves have been prepared to show the rates and quantities that can be pumped over the divide by means of dams of varying heights. From these the shortages during low water periods have been noted and a suitable storage capacity calculated.

The height of lift will, of course, depend upon the location of the dam, but for purposes of calculation, it has been assumed that the water will be pumped directly from the back water of the dam and that the lift will be reduced by this height. An extra ten feet have been allowed to provide for storage in the reservoir up to contour 1963 or an available depth of 15 feet.

The water level in the river at the time of the survey was 1,668·85 referred to the datum of the Canadian Pacific railway, Outlook branch, while the top of the pipe was taken as 1,973 at the intake basin for the gravity line, giving a lift of about 304 feet from the natural river surface. This can be reduced as much as the height of the dam, if the dam is built near the intake, if not, it will of course be between 270 and 304 feet. For purposes of calculation lifts of 261 and 271 feet were taken.

As will be seen from the pumping curves, there will be for some seven or eight months in the year a large excess of power available but, during the winter months,

there will not be sufficient power unless the dam is carried to a height of 50 or 60 feet. As a good reservoir site is available, this would not only be an unnecessary expense but would provide a large excess of power during all but the lowest water periods, unless it were found desirable to utilize such power for other purposes.

While no attempt has been made to design or select a type of dam for this work, owing to lack of information as to the depth to which the quicksand extends in the river bed, it may be said that a dam 35 feet high will provide enough power to raise a flow of 205 cubic feet per second over the divide and that this flow has been taken as the ultimate requirement of the district.

Calculations from the available information and old high-water marks gives a flood flow for this river of 145,500 cubic feet per second, so that probably a spillway capacity of 200,000 cubic feet per second should be provided.

Cross-sections, profiles and contour plans accompanying this report show the topography of the river valley in the vicinity of the pipe line intake, the contours having been developed to 60 feet above water level and soundings having been taken through the ice. However, before an intelligent estimate or design can be made it will be necessary to have extensive borings made, both in the river bed and in the banks, to ascertain exactly what class of material will have to be dealt with. As will be noted from the profiles showing the result of borings taken at points lower down the river, the depth of quicksand is, in places, considerable and varies greatly.

In connection with the construction work, a considerable item will be the difficulty of obtaining suitable material for concrete in the vicinity of the river. Sharp sand appears to be almost impossible to obtain within 10 or 15 miles; gravel in large quantities is also at a considerable distance and, without test pits, it is impossible to ascertain whether, even at the points noted, a large supply can be obtained.

Some coarse, sharp, red sand appears in a pit dug in the river bank on section 30, township 21, range 7, west 3rd meridian, almost at water level, but it was impossible to estimate the quantity available without borings or numerous pits.

At the present time the haul for cement, steel and lumber for forms, &c., would be lengthy, probably 40 miles, over poor trails, so that this item would add greatly to the cost of structures. However, a new railway line, as shown on the accompanying map of the district, will reduce this distance very materially, and it is probable that before construction could possibly be commenced, this line will be in operation and material could be delivered at the works by means of short spurs.

ESTIMATED POPULATION.

Canada.				Alberta and Saskatchewan.			
Year.	Population.	% Increase.	Total Increase.	% To Provinces.	Increase in Provinces.	Total in Provinces.	Remarks.
1871	3,485,761						
1881	4,324,810	24·77	839,049				
1891	4,833,239	11·76	508,429				
1901	5,371,315	11·14	538,076			164,301	
1911	7,204,838	34·13	1,833,523	38·33	702,794	867,095	
1921	9,727,000	35·00	2,522,162	40·00	1,008,800	1,875,800	Estimated.
1931	13,034,000	34·00	3,307,000	35·00	1,157,500	3,033,300	"
1941	17,205,000	32·00	4,171,000	34·00	1,418,100	4,451,400	"
1951	22,367,000	30·00	5,152,000	33·00	1,703,500	6,154,909	"
1961	28,630,000	28·00	6,263,000	30·00	1,878,900	8,033,800	"
1971	36,360,000	27·00	7,730,000	25·00	1,932,500	9,966,300	"
1981	48,814,000	26·00	9,454,000	22·00	2,079,900	12,046,200	"
1991	57,268,000	25·00	11,454,000	20·00	2,290,800	14,337,000	"
2001	71,012,000	24·00	13,744,000	20·00	2,748,800	17,085,800	"
2011	87,345,000	23·00	16,333,000	20·00	3,266,600	20,352,400	"

ESTIMATED URBAN POPULATIONS MOOSEJAW AND REGINA DISTRICTS.

Year.	Increase in Provinces.	% to Districts.	Increase in Districts.	% Urban.	Urban. Increase.	Total Urban.	Total Urban from curves.
1911	702,794	22·03	154,819	35·82	45,781	49,718	
1921	1,008,800	15·00	151,320	55·00	83,200	132,900	183,000
1931	1,157,500	12·00	138,900	65·00	90,300	223,200	260,000
1941	1,481,100	10·00	141,800	70 00	99,300	322,500	342,000
1951	1,703,500	8 25	140,500	75·00	105,400	427,900	430,000
1961	1,878,900	"	155,000	75·00	116,300	544,200	550,000
1971	1,932,500	"	159,400	80·00	127,500	671,700	
1981	2,079,900	"	171,600	90·00	154,400	826,100	
1991	2,290,800	"	189,000	100·00	189,000	1,015,100	
2001	2,748,800	"	226,800	110·00	249,500	1,264,600	
2011	3,266,600	"	269,500	120.00	323,400	1,588,000	

POPULATION ESTIMATES.

In the consideration of this project, a subject of much interest is the population that must be provided for and, in this connection, a series of estimates and curves have been prepared from the available data. Unfortunately the census returns for western Canada are very incomplete previous to 1901 and, in fact, until 1905, when the provinces of Alberta and Saskatchewan were formed, so that it is a difficult matter to satisfactorily base any deductions upon the rate of increase shown by these returns.

The employment of some other method of estimation was thus necessitated and it was finally decided to deal with the whole problem on a basis of percentages of the total population of Canada, estimating that this factor would increase in a manner similar to that of the population of the United States during the past one hundred years.

As will be seen from the accompanying tables, the increase in the population of Canada, during the decade 1901 to 1911, amounted to 34·13 per cent of the population in 1901, or to 2·98 per cent per annum. Assuming that this rate of increase will be maintained for the next twenty years, then gradually decreasing, as was the case in the United States, it was found that the population of Canada, one hundred years hence, would be over eighty-seven millions.

During the last decade, the provinces of Alberta and Saskatchewan absorbed 38·33 per cent of the total increase in Canada and the population is increasing more rapidly in these provinces than in other parts of the Dominion. It was assumed therefore that this percentage would be somewhat larger during the next ten years and then be gradually reduced until it reached the same ratio to the increase in the Dominion as the area of the provinces bears to the area of the Dominion, *i.e.*, 20 per cent.

The increase in the districts of Moosejaw and Regina during the period 1901 to 1911, amounted to 22·03 per cent of the total increase in the two provinces but, as these districts are now comparatively closely settled, it can be assumed that this rate of increase will not be maintained, but will fall gradually until the ratio of increase is the same as the ratio of their area to the area of the two provinces, *i.e.*, 8·25 per cent.

From the latest census bulletin it will be noted that the urban increases in the different provinces of the Dominion bear the following relation to the total increases in the provinces during the past ten years.

	Per cent.
In Saskatchewan the urban population increase was of the total increase..	28·37
In Alberta the urban population increase was of the total increase..	40·22

	Per cent.
In Manitoba the urban population increase was of the total increase	64·82
In Ontario the urban population increase was of the total increase	115·3

As conditions in the Moosejaw and Regina districts are now approaching the conditions in Manitoba, it is assumed that the urban increase for the next decade will represent 55 per cent of the total increase, then gradually rising until the towns begin to draw from the country, as is the case in Ontario at present.

There are also included in this report three sets of, probably, self-explanatory curves, although, possibly, it might be pointed out that the curves showing the estimated population of Canada and of the provinces of Alberta and Saskatchewan are plotted from the results of the above estimates, while the curves showing the urban population of the districts are projected according to the present rate of increase and differ somewhat from the tabulated estimate. The curves showing the population of the cities have not been projected beyond the present date, excepting in the cases of Regina and Moosejaw.

With these explanations it is hoped that the tables and curves can be understood and it is noteworthy that since the census of 1911, the increases in the population of Canada, due to immigration alone have been somewhat greater than the total increases worked out here. When the curves of other Canadian cities are studied, it will be noted that as the cities become larger, the population curve flattens rapidly and, in the case of the cities of Regina and Moosejaw, the curves have been projected so that they will become more nearly vertical than those of the larger cities.

From these facts it is considered the estimates are conservative and that it is quite possible the smaller supply system may be taxed to its capacity even before the date estimated. It also becomes apparent that a large urban population should be expected in this district if no factors arise preventing an increase such as is indicated by the growth of other cities similarly situated. An early consideration of a system of permanent water supply is therefore most important, as such a project will take years to construct and the present sources have already proven inadequate, making this question one of the factors affecting the growth of the district in the immediate future.

ESTIMATES.

In carrying out estimates on this project two objects have been kept in view, viz., the provision of a supply serving both the population of the district for the next twenty-five to thirty years and the estimated ultimate demands of the district. With this in view the present estimates were made for the supply of 60 cubic feet per second or 32,280,000 gallons per diem, which, it is estimated, will serve the district until 1941 with a per capita supply of 100 gallons per diem.

The second estimate, for 200 cubic feet per second, which will, it is thought, be the amount eventually demanded, is not so carefully carried out, and only rough approximations of the earth work and details of structures have been worked out. The interest on the extra outlay for such a scheme during the period before it becomes necessary would amount to much more than the cost of a new pipe at a later date, when it would be needed, so that it is scarcely deserving of more than passing comment so far as an estimate of cost is concerned.

However, it would be as well to make the necessary reservations for right-of-way and provisions for reservoir space, power development and such other matters, costing at the present time comparatively little more than in the case of the smaller scheme. This applies especially to the reservation of a sufficiently wide strip of land to provide ample spaee for further enlargement, also to the reservation of land for reservoir

sites, pumping stations and areas flooded by increased lift on the dam in the event of this structure not being carried up to its full height at the present time.

If the dam were constructed to full height it is probable that the excess power could be utilized in the district to such advantage as to more than pay the interest charges, depreciation and sinking fund on the greater amount of equipment necessary and that it would, within a very short period, prove a great benefit to the district in ways other than actual money return, being an inducement to industries to establish in the cities with available cheap power. Time will not permit of a detailed study of this phase of the question, and it is merely advanced as a suggestion having, possibly, a great influence on the design of the water supply scheme.

WATER REQUIRED.

At the present time, as previously mentioned, the per capita supply in the cities and towns of this district is very low and, judging from American practice there is every indication that it will be largely increased so soon as a good supply can be obtained.

Mr. John R. Freeman, in his report on the Hetch Hetchy water supply system for San Francisco, made the following comment on this question:—

> 'The quantity of water actually used per capita is found to increase from year to year in, substantially, all growing cities in the United States, and is showing a similar although slower rate of increase in most European cities. This comes naturally with the higher standards of comfort, with more bath-tubs, more water fixtures in the dwellings, and in most American cities the rate of increase has far outrun the expectations of twenty years ago. Even when a metre is installed on every tap, soon after the immediate drop, the curve of per capita consumption again begins to rise and, so soon as the water supply of a city is put on the rational basis of sale only by metre, there is no reason why the city should not encourage the most liberal use, particularly if it very properly adjusts its schedule of rates so as to make this a source of income which could be applied to the embellishment of the city.
>
> 'The writer, having had occasion to study this question of future per capita increase in relation to the water supplies of Boston, New York, Baltimore and other cities, cannot regard it as prudent to estimate on a smaller supply for the San Francisco of, say, fifty years hence than from 125 to 150 gallons per capita per day, although by that time substantially every system is metred.'

He further gives the following table, 'Consumption of water in various cities of the United States':—

Name of city.	Daily consumption per capita gallons.	For year.
Denver	213	1911
Pasadena	127	1911
Los Angeles (metered)	130	1910
Cincinnati	127	1911
Salt Lake City	243	1912
Philadelphia	210	1911
Colorado Springs	202	1911
San Diego	104	1912
Cleveland (metered)	104	1911
Washington, D C	178	1911
Baltimore	115	1911
Portland, Oregon	83-86	1910-11
Boston	130	1910
Milwaukee	111.9	1911
St. Louis	118	1911
New York (Manhattan and Bronx)	120	1910
Chicago	230	1909
Buffalo	322	1906
Oakland and adjacent (80 from Peoples Water Co. 30 from wells).	114	1910
San Francisco (85 from Spring Valley Water Co.) (13 from wells and 2 from Golden Gate Park Waterworks.)	100	1910

It should therefore be quite apparent that the 100 gallons per capita per diem figured on in this estimate is quite conservative, and that there is a probability of this consumption being exceeded within the next thirty years.

On this basis the estimate of the size of the supply system has been worked out, and, together with this and the small grade available to carry a supply to Regina and the south country. the size of the pipe becomes established if provision is to be made for, say, twenty-five years expansion.

The accompanying tabulated list of pipe capacities have been figured out carefully according to the Kutter & Chezy formulæ and it can be seen that a pipe 7 feet internal diameter will be required to supply the population of the immediate future, if the estimates of population are approximately correct.

The estimate for the reservoir, intake pipe line, line to the reservoir, and excavation have all been figured to correspond with this quantity and a rough estimate of the cost to supply the ultimate demands of the district has been prepared.

PREVIOUS ESTIMATE OF COST.

In previous reports, the estimates of cost range from $5,000,000 to $13,000,000 and it seems that, owing to lack of information, these estimates were all too low, if the scheme to supply the ultimate demand is considered.

Concrete Pipe. N—0.013.							Wood Stave Pipe. N—0.011.		
Diam.	Vr.	Vs.	C.	Velocity.	Area.	Discharge.	C.	Velocity.	Discharge.
5′0″	1·118	·01	114	1·27	19·64	25	....	....	....
6′0″	1·225	·01	120	1 47	28·27	41·6	144	1·76	49·75
6′6″	1·275	·01	122	1·55	33·18	51·4	146	1·86	61·7
7′0″	1·323	·01	123	1·63	38·48	62·7	148	1·96	75·4
7′6″	1·369	·0257	128	4·5	44·18	199·7	....	....	....
7′6″	1 369	·01	125	1·71	44·18	75·5	....	....	....
8′0″	1·414	·01	127	1·80	50·27	90·5	151	2·14	107·6
8′6″	1·456	·01	128	1·86	56·75	105·7	....	....	....
9′0″	1·500	·01	129	1·94	63·62	123·4	153	2·30	146·3
10′0″	1·581	·01	132	2·09	78·54	164	155	2·45	192·4
10′6″	1·620	01	133	2·15	86·59	186	156	2·53	219·1
11′0″	1·656	·01	134	2·22	95	210	....	....	....
11′9″	1·714	·01	136	2·33	108·43	253	....	....	....

Diam.	Thickness.	Area Circular.	Area. Octogonal.	Total area.	$12.00 per yd.	$15.00 per yd.
5'0"	8"	5·92 sq. ft.	6·81 sq. ft.	12·73 sq. ft.	$ 5.66	$ 7.07
6'0"	8"	6·98 sq. ft.	8·14 sq. ft.	15·1 sq. ft.	$ 6.71	$ 8.39
6'6"	8"	7·5 sq. ft.	8·90 sq. ft.	16·4 sq. ft.	$ 7.29	$ 9.11
7'0"	8"	8·00 sq. ft.	9·5 sq. ft.	17·5 sq. ft.	$ 7.78	$ 9.72
7'6"	8"	8·54 sq. ft.	10·23 sq. ft.	18·77 sq. st.	$ 8.34	$10.43
8'6"	8"	9·38 sq. ft.	11·67 sq. ft.	21·1 sq. ft.	$ 9.38	$11.72
10'	10"	14·5 sq. ft.	17 sq. ft.	31·5 sq. ft.	$14.00	$17.50
11'	11"	17·25 sq. ft.	20·70 sq. ft.	37·95 sq. ft.	$16.89	$21.11
11'9"	12"	20·05 sq. ft.	24·10	44·15 sq. ft.	$19.61	$24.52

OUTLINE OF SCHEME RECOMMENDED.

The scheme adopted for purposes of estimation includes a dam in the river to generate sufficient power to lift the required amount of water over the height of land, through a steel pressure pipe, to a settling basin to be constructed in Shellstone Creek valley. Thence a reinforced concrete pipe having about 25 per cent greater capacity than the estimated requirement of the district will be run to the large reservoir. The idea of the pressure pipe and reservoir supply pipe being of extra capacity, is to provide for the storage of water in the reservoir during high water periods, to supply the full demand during the low water months, and thus decrease the height of dam which would otherwise be necessary. A by-pass of such capacity as to supply the full estimated demand is provided around the reservoir and would be used in the event of it ever becoming necessary to shut down the reservoir for any reason.

Through the reservoir it is proposed to run a pipe three feet in diameter to carry off the surface drainage of Thunder valley above this point. From the south end of the reservoir site a reinforced concrete pipe carrying the full quantity of water demanded by the district is carried to a point on the line nearest Moosejaw, where delivery will be made to that city and the size of pipe reduced. From this going to Millstone, deliveries are made to the various towns and the pipe size is again reduced at the latter point to the smallest size, which is carried into Regina.

The following tabulated list will show the size figured on, both for the immediate supply, and for the ultimate supply.

DAM.	PRESENT.	ULTIMATE.
	35 feet high.	35 feet high.
Pressure pipe 3,700' long	5' 8" inside diam.	10' 4" inside dia.
Concrete pipe to reservoir 67,349 feet	7' 6" " "	11' 9" " "
" by pass, 18,242 feet	6' 0" " "	7' 6" " "
" through reservoir 17,600 feet	3' 0" " "	3' 0" " "
" to Moosejaw 365,709 feet	7' 0" " "	11' 0" " "
" to Milestone 360,379 feet	6' 0" " "	10' 0" " "
" to Regina 170,518 feet	5' 0" " "	8' 6" " "
Reservoir area	337.6 acres.	1,250 acres.
Capacity	2,913 acre feet.	18,750 ac. ft. app.

CALCULATIONS.

Dam and Power Required.—As previously stated, it may prove better to put in the dam and power plant large enough to pump the supply of water which will be needed eventually, and the following figures are based on this assumption to show

that the scheme is practicable for the ultimate requirements of the district which can be served:—

Ultimate consumption—200 c.f.s.

Evaporation on reservoir—18″ net over 1,250 acres = 1,875 acre feet per year or 2·59 c.f.s.

Allow another 2·41 c.f.s. for seepage and other losses and there will be 205 c.f.s. required to supply to the reservoir over a 271 foot lift.

With the weight of water assumed at 62·4 pounds per cubic foot, the power requirements are as follows: 12,792 pounds of water to be raised 271 feet per second = 3,466,632 feet pounds per second = 6,302 H.P. at outlet of pressure pipe. Assuming 5 per cent friction loss in pipe, efficiency of turbines, 85 per cent, efficiency of electrical machinery, 90 per cent, efficiency of pumps, 80 per cent, we have a combined efficiency of 58·1 per cent in the whole system, requiring 10,846 water horse-power to do this work, or 2,731 cubic feet of water per second over a 35 foot dam.

Curves showing the daily quantities of water which can be pumped during the low-water season are included in this report, and these were arrived at on the above basis.

PIPE DESIGN.

The style of concrete pipe used for purposes of estimation is similar to that adopted and found successful by the United States Reclamation Service, and on checking the stresses it was found that the amount of steel used was somewhat more than actually needed to take up the internal stresses due to the hydrostatic head, but it is probable that unexpectedly high temperature stresses may develop, especially while the pipe is being constructd, and the surplus steel will serve a very useful purpose in this respect.

PIPE LINE AS ESTIMATED FOR IMMEDIATE FUTURE.

Quantity to be supplied—

Moosejaw..	25	c.f.s. or	13,500,000	gallons per day.
Regina..	25	" "	13,500,000	"
Milestone, Weyburn and adjoining towns..	10	" "	5,380,000	"
Total..	60	" "	32,380,000	"
Add to allow for pipe losses..	2·5	"		
Add to allow for reserve in reservoir	12·5	"		
Total..	75·0	"	to be pumped.	

Assuming the velocity in pressure pipe at 3 feet per second, this pipe must be 5 feet 8 inches in internal diameter.

To carry 75 c.f.s. on a 1 in 10,000 grade, to the reservoir, will require a concrete pipe 7·5 feet internal diameter, assuming the value of n = ·013 in the Kutter formula.

To carry 62·5 c.f.s. from here to Moosejaw will require a pipe 7 feet internal diameter. From this point to Milestone to carry 37·5 c.f.s. requires a pipe 6 feet in diameter, changing to a 5-foot pipe into Regina .

RESERVOIR.

The reservoir for the initial scheme covers an area of 337·6 acres up the 1,960·00 contour, and will contain some 2,913 acre feet, or 790,662,000 gallons. This quantity

will supply the full demand for some twenty days, if anything should occur to prevent water being pumped for that time, or will act as an auxiliary supply during periods when the full supply is not being obtained from the pumps.

In the reservoir for the ultimate scheme as shown on the accompanying plans, the details are as follows:—

Area to contour..	1960·00	=1,250 acres.
Top of intake pipe..	1964·50	
Bottom..	1957·20	
Bottom outlet..	1945·20	
Reservoir can be filled to..	1963	
Reservoir can be drained to..	1948	
Depth available for use	15 feet.	
Approximate capacity..		18,750 acre feet.

or 5,088,350,000 gallons, which will supply one hundred million gallons per day for 51 days.

In this connection it will be noted from the pumping curves that the shortage of water which could have been pumped by the low water flow of the South Saskatchewan river, during the period, November 1, 1911, to April 30, 1912, estimating that 200 c.f.s. were required, would have been 9,951 acre feet or about half the reservoir capacity. In calculating these figures it was assumed that the full flow of the river would be utilized for power and the shortage would be increased by about 10-12 per cent if the 200 c.f.s. were taken out above the dam, as will probably be the case. This shortage would require the pumping capacity of 250 c.f.s. for 112 days to refill the reservoir, and from the hydrographs it can be seen that this will be easily obtainable.

COST DATA.

As this season's work was only of a preliminary nature, it was not possible to make any detailed examination into the natural conditions along the line and such notes as are given must be understood to have been taken from surface indications. The natural surface has been described and some notes on the quality of soil given previously in this report, but here more particular attention will be given to matters affecting cost of construction.

As before mentioned, the soil in Thunder valley is for the most part heavy clay containing a quantity of alkali in places, and below the point where the valley turns south is sticky and hard to handle, if wet. Along the banks of the lakes where the location is run, there is considerable loose rock in the nature of (1) gravel at the first lake, and (2) comparatively large stones and boulders along the others, making, probably, some fifteen miles of more or less difficult excavation if surface indications are to be relied upon.

From the point where the line turns southeast at the north boundary of township 19, range 2, west of the 3rd meridian, the indications are that excavation will be easy, unless quicksand is encountered along that part of the line immediately to the north and south of the railway track east of Mortlach.

In order to obtain a good alignment some 33 siphons have been included, under an average head of 27 feet and one with a maximum head of 83 feet, thus enabling the line to cross the coulees on long tangents and shortening the pipe by disregarding the contour. In other cases comparatively deep cuts have been included for the same reason, as the earth work is comparatively cheaper than the increased length of pipe. This is particularly true of the deep cut north of Mortlach, where a considerable shortening of line was effected, and of the five or six miles of cutting on the east side of Moosejaw creek near Milestone. In this report no attempt has been made to include the costs of culverts, blow-offs, valves, &c., as it is considered that the scheme

is not as yet far enough advanced for such detail work and the preliminary location is always open to revision and improvement in alignment, making it impossible to give accurate figures on such details.

DAM.

As previously stated, no attempt has been made to design or work out a detailed estimate for a dam in connection with this scheme owing to lack of information regarding depth of quicksand which would be encountered and this cost has been included as a lump sum—$1,500,000.

STEEL PIPE FROM RIVER TO SETTLING BASIN.

This pipe will have to withstand a hydrostatic head of 270 feet at the river and, assuming the efficiency of a triple-butt or a lock-bar joint at 80 per cent, this requires a thickness of $\frac{5}{16}$ of an inch without making allowance for any weakening from corrosion. Such a pipe will weigh, including rivets, lap, &c., approximately 285 pounds per lineal foot for 5 ft. 11 in. pipe, or 5 ft. 8 in. inside diameter.

To prevent corrosion it will be necessary either to thoroughly coat the pipe with a good asphaltum paint or line it with a rich cement mortar, and this latter method is to be preferred on account of the smooth internal surface thus secured, allowing cheaper methods to be used in the erection of the pipe, since no special provision has to be made to keep smooth joints. Further, the painting method has not as yet proven altogether satisfactory in preventing corrosion on the interior of water pipes.

In estimating for this item it has been assumed that a 1:2 mortar with a wire fabric would be used and a coating $1\frac{1}{2}$ inches thick applied.

This mortar would require per cubic yard (assuming 3·8 cubic feet of cement per barrel):—

31 barrels cement at $3.15 per barrel	$9 76
0·87 cubic yards sand at $1.25 per cubic yard	1 09
Mixing, hauling, pouring, and plant	3 15
	$14 00

As this pipe will require 0·09 yards of concrete per lineal foot, the cost of lining will be as follows:—

0·09 cubic yards concrete at $14	$1 26
Add for setting up and taking down movable forms, per lineal foot	30
Wire reinforcement, per lineal foot	30
Total, per lineal foot	$1 86

COST OF STEEL.

With regard to the cost of steel, the following cost data taken from the costs of the Los Angeles steel aqueduct will prove of interest:—

Pipe, 9·25 feet to 11 feet diameter, steel ¼ inch to ½ inch in thickness.

	Per 100 lbs.		
Steel, rolled, punched and delivered at siding ..	$2 45	to	$3 03
Loading and unloading..	06	"	19
Wagon haul..	07	"	07
Placing..	40	"	44
Riveting..	28	"	41
Caulking..	03	"	06
Painting..	03	"	21
Equipment and tools..	18	"	86
Superintendence (local)..	02	"	25
	$3 52	"	$5 52
Cost of excavation per foot run..	$1 02	to	$1 96.

The cost of the Dove creek and San Antonio pipes, which were built by contract and are 9 feet in diameter, ¼ inch in thickness and 1,727 feet long, amounted to $5.81 per hundred pounds of steel. As these pipes were constructed under conditions more favourable than can possibly be expected here, where the long railway haul will materially affect the cost of steel, even though the labour costs will probably be about the same, it is considered that $7.25 per hundredweight is not too much to figure, in this case, for the pipe erected. The excavation, in as much as the pipe must be buried six feet on account of the greater danger from frost, will be about as follows per lineal foot:—

2·7 cubic yards excavation at 30 cents per cubic yard.. ..	$ 81
Back fill 2·7 cubic yards at 10 cents per cubic yard..	27
Trimming by hand, per lineal foot..	20
	$1 28

Or, say, $1.30 per lineal foot.

The total cost per lineal foot of pipe will, therefore, be as follows:—

Steel, 285 lbs. at $7.25 per 100..	$20 66
Concrete lining, 0·09 cubic yards at $14 per cubic yard..	1 86
Excavation, back filling and trimming..	1 30
Total cost per lineal foot of pressure pipe..	$23 82

In estimating the cost of the concrete pipe a 1:3:4 mixture of concrete was adopted, not because these were the best proportions, as they will have to be determined by experiment with the materials found on the ground to get the most dense mixture, but as a basis on which to figure unit costs. It may, and probably will, be found that some other mixture such as 1:2½:5 or 1:2:4 will be more suitable, but these figures should give the average cost fairly closely.

In a scheme of this size and with such location, the cost of cement will be the largest single item, and it was estimated that it could be delivered on the cars at $3 per barrel, and the haulage was estimated at from 15 cents to 40 cents additional, depending upon the distance of the work from the railway.

Sand has been estimated to cost, including haulage, from $1.25 to $2 per cubic yard in the stock pile, while rock will probably cost $1.75 to $3 per cubic yard.

Twisted steel bars are estimated to cost $2.75 per hundredweight on the cars, and haulage has been allowed from 7 to 15 cents per hundred or, roughly, 7 cents per ton mile. The other costs have been worked out from unit costs given on similar works, applying the cost of materials, labour, &c., as found under western Canadian conditions.

The cost per yard of concrete is arrived at as follows:—

1·25 barrels of cement..	$3 94	to	$4 25
0·53 cubic yards of sand..	66	"	1 36
0·7 cubic yards of rock..	1 20	"	2 13
59 lbs. ½-inch twisted steel bars..	1 67	"	1 77
Placing steel..	12	"	15
Bending steel and welds..	24	"	35
Mixing, dumping, spreading and ramming.. ..	85	"	95
Forms, labour and materials..	1 85	"	2 00
Moving forms..	30	"	30
	$10 67	"	$12 96
Superintendence and contingencies..	1 33	"	2 04
Total..	$12 00	"	$15 00

Under the head of contingencies will probably come the supply of water for the mixers as, in some cases, this may be difficult to obtain and may increase the cost of the concrete considerably.

WOODEN PIPE.

The cost of wooden pipe of 7 ft. internal diameter f.o.b. Moosejaw, and constructed of 3½-inch x 6-inch fir lumber with ⅝-inch two-piece bands is quoted at $8.50 per lineal foot when designed to carry a head of 10 feet, and at this rate there will be little or no saving over concrete, while on the other hand, the life of the pipe will be much shorter.

EXCAVATION.

For the most part the excavation will be through dry earth and no difficulty is anticipated in doing most of the work by means of a steam shovel, so that all the trench work has been figured at 30 cents per cubic yard for excavation, 10 cents per cubic yard for backfill, 2 cents per cubic yard for overhaul per 100 feet, and 10 cents per lineal foot for trimming.

In the case of the reservoir embankments, where the earth will be easy to handle and, in the case of the stripping of the reservoir bottom, 20 cents per cubic yard is allowed with 1½ cents per yard for averhaul per 100 feet.

The excavations along the present line have been calculated from the profile for each 100 feet and cross-sections taken from the contours along the projected line as shown on the working plans, which are on too large a scale for inclusion in this report. The results are only approximate as no cross-sections were taken in the field. nor was the final location staked out.

TABULATED ESTIMATE OF COST. CONCRETE AT $12.00 PER YARD.

Division.	Part.	Dimensions.	Quantities.	Unit Costs.	Cost.	Cost for Division.	Total Cost.	Remarks.
				$ cts.	$ cts.	$ cts.	$ cts.	
A.	Dam & Power plant.				1,500,000 00			Assumed.
	Pressure pipe.	5 ft. 8 in. inside diam.	3,700 ft	23 82 per lin. ft.	88,134 00			
	Settling basin.				50,000 00	1,638,134 00		Assumed.
1	Concrete pipe.	7·5 ft. inside diam	68,001 ft.	8 34 per ft.	567,128 34			Gravity pipe. Settling basin to reservoir.
1	Concrete pipe.	3 ft. 0 in. inside diam	17,600 ft	1 55 " "	27,280 00			
	Excavation.	Variable	295,768 cu. yds.	0 40 per yd.	118,307 20			Pipe to dispose of surface run-off.
	Borrow.		3,360 " "	0 25 " "	846 00			
	Excavation.		58,667 " "	0 30 " "	1,760 00			
	Reservoir dams (2).	Each 2,200 ft. long, 731 sq. ft cross-section.	90,000 " "	0 20 " "	18,000 00			Approximate dimensions.
	Cleaning reservoir.	234 acres, 2 ft. deep.	1,110,000 cu. yds.	0 22 " "	244,200 00	977,515 54		
2	Concrete pipe.	6 ft. inside diam.	23,190 ft.	6 71 per ft.	155,604 90			By pass.
	Excavation.	Variable.	124,528 cu. yds.	0 40 per yd	49,811 20			
	Overhaul.		1,287 " "	0 02 " "	25 74			
	Borrow.		9,009 " "	0 25 " "	2,252 20	207,694 04		
3	Concrete pipe	7 ft. inside diam.	380,109 lin. ft.	7 78 per ft.	2,957,248 02			Gravity line reservoir to Moosejaw.
	Excavation.		1,334,494 cu. yds	0 40 per yd	533,797 60			
	Overhaul.		48,610 " "	0 02 " "	972 20			
	Borrow.		334,907 " "	0 25 " "	83,726 75	3,575,744 57		
4	Concrete pipe.	6 ft. inside diam	360,379·3 lin. ft.	6 71 per ft.	2,418,145 10			Gravity line Moosejaw to Milestone.
	Excavation.		545,541 cu. yds.	0 40 per yd.	218,216 48			
	Overhaul.		716 " "	0 02 " "	14 32			
	Borrow		810,324 " "	0 25 " "	202,581 00	2,838,956 82		
5	Concrete pipe.	5 ft. inside diam.	170,518·5 lin. ft.	5 66 per ft	965,134 71			Gravity line Milestone to Regina.
	Excavation.		476,058 cu. yds.	0 40 per yd	190,423 20			
	Borrow		46,737 " "	0 25 " "	11,684 25	1,167,242 16	10,405,287 13	
		Trimming 982,000 ft. at 10c. per ft			98,200 00	98,200 00	98,200 00	
		Engineering 5 per cent			525,164 38	525,164 38	525,164 38	
					11,028,661 51	11,028,661 51	11,028,661 51	
		Right of way and contingencies			471,338 49	471,338 49	471,338 49	
		Total			11,500,000 00	11,500,000 00	11,500,000 00	

SUMMARY OF COST ESTIMATE. CONCRETE AT $15.00 PER CUBIC YARD.

Division	Part.	Dimensions.	Quantities.	Unit Costs.	Cost.	Cost for Division.	Total Cost.	Remarks.
				$ cts.	$ cts.	$ cts.	$ cts.	
A.	Dam & Pumping plant				1,750,000 00			Assumed.
	Pressure pipe	5 ft. 8 in. inside diam	3,700 ft	25 00 per lin. ft.	92,500 00			
	Settling basin				62,500 00	1,905,000 00		Assumed.
1	Concrete pipe	7 ft. 6 in. inside diam	68,001 ft	10 42 per lin. ft.	708,570 42			Gravity pipe, settling basin to reservoir.
	Concrete pipe	3 ft. inside diam	17,600 ft	1 94 " "	34,144 00			Pipe to dispose of surface run-off.
	Excavation	Variable	295,768 yds.	0 40 per cu. yd.	118,307 20			
	Borrow		3,360 "	0 25 " "	840 00			
	Excavation		5,866·7 "	0 30 " "	1,760 00			
	Reservoir dams (2)	Each 2,200 ft. long, 731 sq. ft. cross-section	90,000 "	0 20 " "	18,000 00			Approximate dimensions.
	Cleaning reservoir	234 acres, 2 ft. deep	1,110,000 "	0 22 " "	244,200 00	1,125,821 62		
2	Concrete pipe	6 ft. inside diam	23,190 lin. ft.	8 38 per lin. ft.	194,332 20			By pass.
	Excavation	Variable	124,528 cu. yds	0 40 per cu. yd.	49,811 20			
	Overhaul		1,287 " "	0 02 " "	25 74			
	Borrow		9,009 " "	0 25 " "	2,252 20	246,421 34		
3	Concrete pipe	7 ft inside diam	380,109 lin. ft.	9 72 per lin. ft.	3,694,659 48			Gravity line, reservoir Moosejaw.
	Excavation		1,334,494 cu. yds	0 40 per cu. yd	533,797 60			
	Overhaul		48,160 " "	0 02 " "	972 20			
	Borrow		334,907 " "	0 25 " "	83,726 75	4,313,156 03		
4	Concrete pipe	6 ft. inside diam	360,379·3 lin. ft.	8 38 per lin. ft.	3,019,978 53			Gravity line Moose Jaw to Milestone.
	Excavation		545,541 cu. yds.	0 40	218,216 40			
	Overhaul		716 " "	0 02	14 32			
	Borrow		810·324 " "	0 25	202,581 50	3,440,790 75		
5	Concrete pipe	5 ft. inside diam	170,518·5 lin. ft.	7 08 per ft.	1,207,270 98			Gravity line Milestone to Regina.
	Excavation		476,058 cu. yds.	0 40 per cu. yd.	190,423 20			
	Borrow		46,737 " "	0 25 " " "	11,684 25	1,409,378 43	4,850,169 23	
					12,440,568 22	12,440,568 22	12,440,568 22	
	Trimming fill				98,200 00	98,200 00	98,200 00	
					12,538,768 22	12,538,768 22	12,538,768 22	
	Engineering 5%				626,938 41	626,938 41	626,938 41	
					13,165,706 63	13,165,706 63	13,165,706 63	
	Add for contingencies etc., right of way				334,293 37	334,293 37	334,293 37	
	Total				13,500,000 00	13,500,000 00	13,500,000 00	

* ROUGH ESTIMATE OF COST OF LARGE SCHEME (FOR PURPOSES OF COMPARISON ONLY).

Division.	Part.	Dimensions.	Quantities.	Unit Costs.	Cost.	Cost for Division.	Total Cost.	Remarks.
				$ cts.	$ cts.	$ cts.	$ cts.	
A.	Dam and plant				1,500,000 00			Assumed.
	Pressure pipe	10·3 ft. inside diam.	3,700 lin. ft	47 70	176 490 00			Concrete lined steel pipe.
	Settling basin				60,000 00	1,736,490 00		Assumed.
1	Concrete pipe	11 ft. 9 in. inside diam.	67,349 lin. ft.	19 61 per ft.	1,320,713 89			Gravity pipe settling basin to reservoir.
	Concrete pipe	3 ft.	17,600 lin. ft.	1 55 per ft.	27,280 00			Gravity pipe to dispose of surface run-off.
	Excavation		400,000 cu. yds.	0 40 per cu. yd.	160,000 00			
	Borrow		4,200 " "	0 02 " " "	840 00			
	Excavation		5,866·7 " "	0 30 " " "	1,760 00			
	Reservoir Dams (2)		190,000 cu. yds.	0 25 per cu. yd.	47,500 00			Approximate dimensions.
	Cleaning Reservoir		4,033,333 cu. yds.	0 22 " " "	887,333 33	2,445,427 22		
2	Concrete pipe	7 ft. 6 in. inside diam.	18,242 lin. ft.	8 34 per ft.	152,138 28			By pass.
	Excavation		120,000 cu. yds.	0 40 per yd.	48,000 00			
	Overhaul		1,800 " "	0 02 " "	36 00			
	Borrow		13,000 " "	0 25 " "	3,250 00	203,424 28		
3	Concrete pipe	11 ft. inside diam.	365,739 lin. ft.	16 80 per ft.	6,176,825 01			Gravity pipe reservoir to Moose Jaw.
	Excavation		1,700,000 cu. yds.	0 40 per yd.	680,000 00			
	Overhaul		61,000 " "	0 02 " "	1,220 00			
	Borrow		500,000 " "	0 25 " "	125,000 00	6,983,045 01		
4	Concrete pipe	10 ft. inside diam.	360,380 lin. ft.	14 00 per ft.	5,045,320 00			Gravity pipe Moose Jaw to Milestone.
	Excavation		1,500,000 cu. yds.	0 40 per yd.	600,000 00			
	Overhaul		9,000 " "	0 02 " "	180 00			
	Borrow		75,000 " "	0 25 " "	18,750 00	5,664,250 00		
5	Concrete pipe	8 ft. 6 in. inside diam.	170,520 " "	9 38 per ft.	1,599,477 60			Gravity pipe Milestone to Regina.
	Excavation		840,000 cu. yds.	0 40 per yd.	336,000 00			
	Overhaul		2,500 " "	0 02 " "	50 00			
	Borrow		14,000 " "	0 25 " "	3,500 00	1,939,027 60	18,971,664 11	
	Trimming 982,000 lin. ft. at 10c. per ft.					98,200 00		
	Engineering 5%					953,493 21		
	Right of way and contingencies					476,642 68	1,528,335 89	
	Total					20,500,000 00	20,500,000 00	

* All Excavation quantities are only approximate.

ESTIMATE OF ANNUAL CHARGES.

The annual charges against this project, assuming that the smaller scheme would be the first constructed, are here roughly estimated, in order to show that, before the scheme can be completed, the cost of water to the consumer will not be excessive, and this cost will naturally decrease as the population increases and more water is used.

Estimating that the project will cost $12,000,000, which sum could be realized by the sale of 4 per cent bonds running fifty years, the first charge to be considered would be the payment of the interest, or $480,000 per annum.

Owing to the permanent nature of the structures proposed, the main system should give good service for sixty or seventy years at least. Assuming, however, that it will have to be replaced within fifty years, it is found that the sum of $57,360 per annum at 5 per cent will be sufficient to rebuild the whole system at the end of this period.

To provide for the repayment of the bonds it will be necessary to set aside a further $57,360 per annum at 5 per cent to form a sinking fund for this purpose.

Maintenance and operation charges on such a system should be low, and have been assumed at $160,000 per annum.

Totalling these gives the following annual charges against the project, which must be met by either water rates or other revenue if the scheme is to be successful financially:—

Interest on bonds for $12,000,000 at 4 per cent..	$480,000
Sinking fund to replace system in fifty years, interest at 5 per cent..	57,360
Sinking fund to redeem bonds in fifty years, interest at 5 per cent..	57,360
Maintenance and operation..	160,000
Total annual charge..	$754,720

If, however, the dam be constructed to full size at once and the full equipment of power machinery installed, it is estimated that there will be some 6,000 horse-power available for sale at all but the lowest water periods, while, during the major part of the year, there will be much more than this amount available.

Assuming that this power can be sold for $40 net per horse-power per annum, giving an income of $240,000, this leaves the net cost of the water which must be met by the water rates at $514,720.

As it will probably take at least five years to complete the scheme, estimating that the urban population will then have increased to one hundred and seventy thousand, seventeen million gallons per diem will be required. From these figures the cost of delivery amounts to 8·3 cents per thousand gallons or about 4 cents per day for the average family (five).

While this cost is higher than is usually the case in water supply systems, it is not excessive, and it must be remembered that it is the maximum, reducing each year as the population increases and more water is used.

CONCLUSION.

From what has been said in the above report it must be apparent that this project is one of vital importance to the residents of the district and one which must undoubtedly engage their attention in the near future. There can be no question that the present water supply is, even now, inadequate, and unless some action is taken in the near future the development of this section of the western provinces will be seriously affected.

Owing to the large size of the working plans it was impossible to include them in this report. I beg, however, to hand you herewith the following plans in addition to those included:—

S.P.L.	1.	General plan	from 0 + 00	to 2438 + 60·2	
S.P.L.	2.	General plan	from 2438 + 60·2	to 1556 + 00	
S.P.L.	3.	General plan	from 1556 + 00	to 4532 + 00	
S.P.L.	4.	General plan	from 4532 + 00	to 7574 + 00	
S.P.L.	5.	Profile	from 0 + 00	to 2438 + 60·20	
S.P.L.	6.	Profile	from 2438 + 60·2	to 1556 + 00	
S.P.L.	7.	Profile	from 1556 + 00	to 4532 + 00	
S.P.L.	8.	Profile	from 4532 + 00	to 7574 + 00	
S.P.L.	10.	Contour plan and Cross-section Dam Site 'A.'			
S.P.L.	11.	Contour plan and Cross-section Dam Sites B. and C.			

All of which is respectfully submitted.

R. J. BURLEY,
Division Engineer.

REPORT OF T. M. MONTAGUE.

R. J. Burley, Esq.,
Division Engineer,
Department of the Interior,
Calgary, Alta.

Sir,—I beg to submit herewith my report on the South Saskatchewan River Diversion Project.

The survey to locate a route for a gravity line to carry water from the South Saskatchewan river to Moosejaw and Regina was undertaken by the Dominion Government during the summer of 1912. I left Calgary on July 9 for Moosejaw and thence to Tugaske, from where the party was to outfit.

While awaiting the arrival of my camp equipment I made a reconnaissance of the river bank from the Elbow to the foot of the Vermilion hills and a short distance down the Thunder valley to determine what looked to be the best point to bring the water out of the river. This would be controlled by the possible location of a route. The Thunder valley appeared to be the most feasible, especially as the watershed between it and the river was very short and low, making a good place to bring the water over.

The party and equipment began coming in on July 15, but some considerable delay was occasioned by the non-arrival of some of the tents. The complete camp consisted of one engineer, one transitman, one topographer, one draughtsman, two rodmen, two chainmen, one axeman, and one cook, three teamsters, six horses, one wagon, two democrats, six tents, and the various other articles necessary to such a party.

On July 26 a line of levels was started from Tugaske to the river. The Canadian Pacific Railway base of rail at Tugaske was taken as datum, it being the only elevation available, referred to a connected chain throughout the district. A bench mark was established at Tugaske referred to this datum. The levels were then carried back to the river and the bench marks established at various points.

Previous to this, Mr. Gleeson with a rodman had been sent to Swift Current to level back to the river from that point, in order that the fall in the river over a con-

siderable distance could be determined. Mr. Gleeson returned, having completed the work, August 1.

On August 9 the actual work on the preliminary line was started, as already intimated, making the course of the Thunder valley the general course of the line. In this work I took the level myself and kept ahead of the party, picking out points along the line that were on grade. Hubs were put in, the distances chained, angles turned, the profile taken, and the topography of the country immediately adjoining the line developed by means of hand level and rod.

The topography covered where possible at least a difference in elevation of twenty five feet, five, five-foot contours, but where the flatness of the country made this impracticable, four hundred feet on either side of the line was surveyed.

The line from the top of the river bank to the head of the Thunder valley, a distance of five miles, was through a flat country with numerous sloughs and a large portion of it was under cultivation.

Along the bottom of the valley as far as section 36, township 19, range 6, west of the 3rd meridian, the land was a wet, alkaline clay with practically none of it cultivated. From this point to section 5, township 20, range 2, west of the 3rd meridian the line was very rough and stony with but little under cultivation. From this point to the railway the ground was a clay loam practically all of which was cultivated.

The line followed the side hill, or watershed, of the Thunder valley all the way to the railroad which it crosses one and a half miles east of Mortlach. Near here the line ran around a big loop some seven miles long when following the grade, so it was found advisable to make a considerable cut for a shorter distance in order to save the extra length of pipe.

This was completed by September 16 and the camp moved back towards the river where some work remained to be done. A line of levels was run on the return trip to establish permanent bench marks along the route. These were put in at convenient section corners at about six mile intervals.

The land ties, which had been neglected previously in order to save time, were also made.

A site for reservoir was chosen in township 20, range 6, west of the 3rd meridian, and a complete topographical survey made of it, while several alternative lines were run around it.

A line of flying levels was run from the line station in section 19, township 19, range 3, west of the 3rd meridian, to try for a shorter route, but the depth of cut necessary made this diversion inadvisable.

Diverging at a point in section 17, township 21, range 6, west of the 3rd meridian, it was seen that probably a better line could be obtained by striking the river a mile further north at the mouth of the Shellstone creek. This line was surveyed and adopted, as it required less cut and was shorter than the original plan.

This line was carried down to the river and a traverse made of the east bank for a mile or so, which included one of the possible locations for a dam. Another dam site some three miles further down the river was also roughly surveyed; as there was no means of crossing the river at this point, no soundings could be taken, or surveys made of the western bank.

On November 13 the work laid out was completed and the party disbanded. The outfit was shipped from Tugaske to Maple Creek for storage. I returned to Calgary, November 25.

Mr. B. Russell, B.Sc., completed the survey to Regina from the Canadian Pacific Railway's main line at Mortlach.

The winter work has consisted of finishing up plans, profiles, and making an estimate of excavation necessary to lay pipe.

During the winter Mr. Gleeson went back to the Saskatchewan river and surveyed the dam sites, one in section 15, township 23, range 7, west of the 3rd meridian, and another in section 6, township 22, range 7, west of the 3rd meridian, and the third in section 19, township 21, range 7, west of the 3rd meridian and section 24, township 21, range 8, west of the 3rd meridian above Riverside, taking soundings across the river and developing an accurate section.

Respectfully submitted,

T. M. MONTAGUE.

REPORT OF B. RUSSELL.

R. J. Burley, Esq.,
Division Engineer,
Department of the Interior,
Calgary, Alta.

Sir,—I beg to submit the following report of work done by my party upon the survey of a pipe line from the South Saskatchewan river to Moosejaw, Regina and the surrounding country.

In accordance with instructions received from the Commissioner of Irrigation, after having completed all the surveys in connection with the Belly-St. Mary river diversion canal, my party and equipment was shipped to Mortlach, Sask., about the first of September, from which point a preliminary line run from the South Saskatchewan river under the charge of Mr. Montague, B.Sc., was to be continued by us to Regina.

It was found necessary, in order to carry this work to completion before winter, to materially increase the size of my party, and the following quotations are from a letter written to the Commissioner of Irrigation at that time:—

'To follow the instructions received from Mr. Burley, in connection with carrying on the surveys of the South Saskatchewan diversion canal, it will be necessary to add considerably to my party.

'My instructions are to run a line in a southeasterly direction to a crossing of Moosejaw creek and then in a northerly direction to Regina. I am to take topography over the line, showing five foot contours to a distance of from fifty to one hundred and fifty feet on either side of the centre line, and also to tie my traverse to the land survey lines wherever possible.

'I informed Mr. Burley at Moosejaw that I would require another team and more men in order to carry on this work. He suggested getting a team and teamster at Mortlach, but has given me no authority upon which I feel that I can act, and it is upon his suggestion that I am writing directly to the office concerning this matter.

'The distance by line from Mortlach to Regina, as far as we can tell, cannot be less than 100 miles and will probably be more. From the little we have been able to see of the country it will not be plain sailing to follow a supported grade line to Regina, but several lines will have to be run in places to determine the feasibility or otherwise of the location.

'With my party at present we could only run fifteen miles of line from a camp and then break up the party and cross-section the same. With my present transport, it would take two days to make a fifteen mile move unless we could engage an extra team for this purpose. In this country and at this season of the year, it will be difficult, if not impossible, to engage a team for as frequently as we will require to move camp. I have made some inquiries about engaging a team by the month and am convinced that we cannot get a team and teamster for less than $5 per day, if we can procure one at that.

'The impossibility of our reaching Regina with the line under the present conditions will be obvious to you.'

This letter properly sizes up the situation at that time, and the party was accordingly increased from nine to fourteen men and an extra team added to the equipment.

Owing to delays in procuring the extra men and team it was not until September 16 that we were in a position to run a line. With a full party, however, we were able to run from five to eight miles of line per day. By keeping well ahead of the party myself and using a head picket it was possible to get many long shots, as the speed of the party in most cases depended entirely upon the speed of the levelmen.

The angles were turned to tacks set in wooden hubs driven flush with the ground, and at every angle point the instrument was reversed and the angle doubled to eliminate any possibility of an error.

The topographer had two assistants with him, one on either side of the centre line, and as the country for the most part was fairly flat, had no difficulty in keeping up with the party. The topographical notes were kept in the form of cross-sections in order to facilitate the work, and although the most accurate method of taking topography is to actually locate and sketch the contour in a note book, it was found quicker and more satisfactory not to do so.

It was found convenient only to make land ties with the township or range lines on this work, but careful ties were made at these points and no appreciable error was found in our bearings. Although we had no instructions to this affect, it was understood by us that in order to complete a line to Regina, accuracy would have to be sacrificed to a certain extent for speed, but considerable care was taken throughout the work to avoid any serious errors.

It was known that there was no chance of checking our levels between Mortlach and Milestone, and a close check at Milestone with the Canadian Pacific Railway levels was not expected. Any error in the levels however, will not be sufficient to appreciably change the location of the line one way or the other, and an estimate made from this line should give a fair idea of the cost of constructing a pipe line through this country. Probably 90 per cent of the country through which the line runs is under cultivation and, although the soil, particularly for the first thirty miles, is very light and sandy it appears to be well adapted to the growth of wheat, oats, &c. From Baildon, a small town on the Canadian Northern Railway, onward, the soil is heavier and as Moosejaw creek is approached the soil is a very heavy clay and not well suited to the growth of crops.

It will be seen from the general plan and profiles filed with the Commissioner of Irrigation that the excavation will be light. For the most part the country is very flat and, except for the coulees which will have to be crossed, lends itself to easy curves and grades. Several attempts were made to run around the head of these coulees, but in every case the length of line was greatly increased and in most cases the curvature is too sharp for a pipe line of this size. The most feasible solution of all these crossings seemed to be the adoption of siphons, and although some of the coulees are very deep and wide it will not be feasible to go around them.

Although there may be some gravel and sand in the vicinity, we did not see any whatever that could be utilized in the construction of the works.

Owing to the lateness of the season it was not possible to make the proper investigations of the country between Milestone and Regina, but although there appears from its profile to be some heavy excavation on this section of the line there is every reason to believe that a line can be located through this country so that the work will be fairly light.

Respectfully submitted,

B. RUSSELL,
Inspecting Engineer.

Saskatchewan River Valley Showing nature of Channel between Log Valley and Riverside.

Saskatchewan River Valley, East Bank—Showing nature of banks between Dam Sites "C" and "B".

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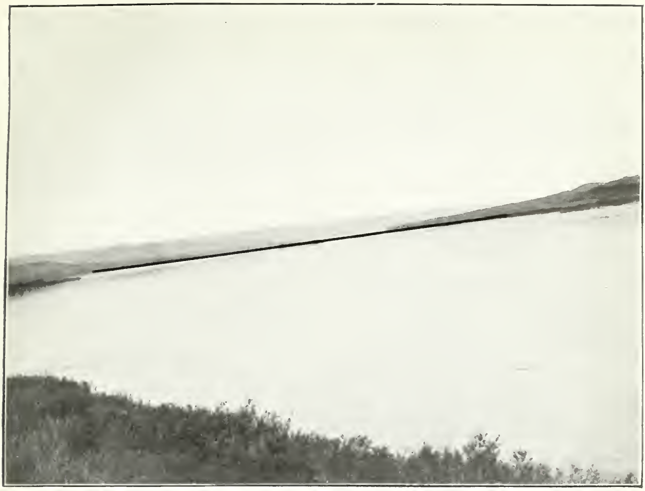
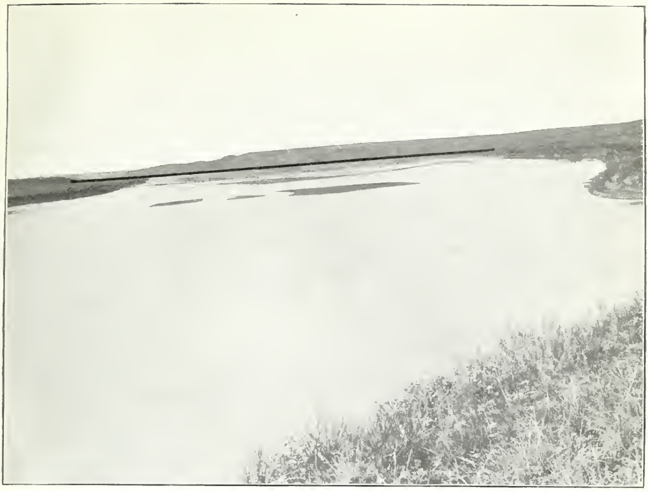


Saskatchewan River Valley—View Upstream to Dam Site "C".

Saskatchewan River Valley—View Downstream from Dam Site "C".



Saskatchewan River Valley—Looking Downstream to Dam Site "C".

Saskatchewan River Valley Looking Downstream to Dam Site "C".

Thunder Creek Valley—Reservoir Site. Tp. 20, Rge. 6 W. 3rd.

Valley of Swiftcurrent Creek near Mouth.

Saskatchewan River Valley—View Upstream from Dam Site "B" to Dam Site "C".

Saskatchewan River Valley—River Banks below Dam Site "C".

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Saskatchewan River Valley—View Upstream from Log Valley.

Saskatchewan River Valley—View Downstream from Log Valley.

Saskatchewan River Valley—View Downstream from Riverside.

Saskatchewan River Valley—View Upstream from Riverside.

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REPORT ON BELLY-ST. MARY RIVER DIVERSION PROJECT, BY B. RUSSELL.

F. H. PETERS, Esq.,
Commissioner of Irrigation,
Department of the Interior.
Ottawa.

INTRODUCTION.

SIR,—In submitting a report upon the project to divert water from the Belly river and empty it into the St. Mary river at some point above the head gates of the Alberta Railway and Irrigation Company's canal, I wish to first point out, that although considerable care was taken with the survey and general plans of this scheme, there was not sufficient time for this report to go into exact details of the various structures which will be required.

Only a general idea of the cost of the structures has been attempted here, but the figures given should represent fairly accurately the cost of construction.

Every feasible route for a canal was investigated by my party while in the field, and I believe that the general location as shown on the plans is correct, and can never be changed to any advantage. Considerable care was also taken in the projecting of the final lines, to make the cuts and fills balance as nearly as possible, but good alignment was not sacrificed for this.

It is impossible to project a line in the field so that the quantities will balance, and the only way to intelligently revise a location in this respect, is to plot a mass diagram, from which information with respect to borrow, waste and overhaul can be obtained. I have no doubt that when such diagrams of this work are plotted, many minor changes will be necessary before the work is actually constructed.

FIELD WORK.

The instructions in starting this work were given verbally, and further instructions are summed up in the following letters from the Commissioner of Irrigation:—

1. 'When you reach Kimball with your line you should tie your levels on to the old government bench mark which was set some years ago just north of the village. I understand that this bench mark is set at or near the headgate, but I think that Mr. Dunn, who lives near the headgate of the canal, can show you where the bench mark is.

2. 'You should reference your levels to the permanent bench mark south of the gauging station at Mr. West's ranch and should leave the permanent iron bench marks that you have, set at convenient intervals along the line of your final location.

3. 'Although you will have numerous ties between your line and the land survey lines, your survey should be referenced at least to two independent star observations, to determine astronomic north. If only two observations are taken there should be one at each end of the line.

4. 'All final levels that are brought in from the field must be circuited, so as to have an absolute check upon their accuracy.

5. 'While you are in the vicinity, you should endeavour to get as complete notes as possible regarding the amount and location of any gravel in the vicinity that would be suitable for utilizing in the construction of the works; and I would also ask you to get close figures of the cost of freighting materials from the end of the railway at Cardston to the different points along the location.

6. 'As taken up with you verbally, you should run sufficient preliminary or final lines to satisfy yourself that you have the best location possible, and every effort must be made to keep the location within Canadian territory.

'Respecting the matter of the quantity of water available in the Belly river at West's ranch during the irrigation season, and also regarding the question of location between the Belly and the Waterton rivers, I am not able to find out definitely what amount of water is available but, beyond a doubt, there will not be sufficient in average years to keep up a continous flow of 500 c.f.s.

'I cannot determine exactly what quantity of water it will be necessary to deliver into the St. Mary river. I have, therefore, decided that we will not attempt to locate a canal between the Belly and the Waterton, but that we will simply determine the feasibility or otherwise of the proposition. You will please run flying levels between the two rivers to determine the relative elevations and the feasibility or otherwise of the diversion from the Waterton river.

'I would ask you to run these levels both ways so as to check them and thus avoid the possibility of an error. Please tie on to the B.M. at the hydrographic measuring station at Waterton Mills and get sufficient notes, so that if feasible you can mark a rough location on the sectional map. Possibly it would be well to do this at once, before the Belly river gets too high to be crossed by your horses.

The party was made up as follows:—

Engineer in charge.	Rodman.
Assistant.	Teamster.
Head chainman.	Axemen (two).
Rear chainman.	Cook.

The party left Cardston, Alberta, on May 1, arriving at Mountain View on the same date. From the little information available about the country, it was decided that our line would in all probability come down the valley of Mami creek, so that it was on this creek that the first camp was made.

During the first few days in camp a reconnaissance was made of the Belly river, and several possible sites for an intake selected. Since it had been decided that storage would be necessary, the most desirable point was the present location as shown on the plans. Some flying levels were run from the river to the height of land between Lee creek and the headwaters of Boundary creek. These levels revealed the following facts:

1. That it would be necessary either to raise the water at the proposed intake, by means of a dam, to a considerable height, or to locate an intake further up the river.

2. That the canal would have to be located on a very flat grade.

3. That even on the flattest possible grade there would be a heavy summit cut.

4. That once over the summit, there would be no difficulty in getting the water to the St. Mary river.

5. That it would be necessary either to take the water across Lee creek on a flume about one hundred feet high or under the creek in a siphon.

From a study of these facts it was concluded to make surveys for a dam and reservoir in sections 4 and 5, township 2, range 28, and to run several preliminary lines from the proposed intake to the summit, before projecting a location.

Owing to lack of help, it was necessary in carrying on the surveys, to first run several miles of traverse, setting stakes at every one hundred feet, and then break up the party and take topography over the same. The centre line was chained and staked, and the angles were turned to tacks set in solid wooden hubs driven flush with the ground. To avoid angular error, not only was the magnetic bearing of each course noted, but at every angle point the instrument was reversed and the angle doubled to eliminate any inaccuracy due to the instrument itself.

Two observations were made on Polaris, one at each end of the line, and the bearings connected with true north. Levels were run over the centre line and temporary

bench marks established at intervals not greater than one-half mile. Beside these temporary bench marks, six permanent bench marks were set at convenient points along the final location.

The elevation of each stake was noted by the levelmen, and also intermediate breaks in the ground along the centre line, so that an accurate profile of the centre line could be plotted.

Five foot contours were located on either side of the centre line to a sufficient distance to obtain the necessary information to project a location. The contours were sketched in a note book showing the distance from the centre line to each.

Every evening the day's work was plotted upon the plans, so that no time would be lost in projecting a paper location.

After several preliminary lines were completed between the proposed intake and the summit, and all the available information plotted on the plans, a location was projected, using circular curves as best suited the general bend of the country, but frequent and sharp curves simply to eliminate small cuts were avoided, and the location made to fit the general contour of the country, rather than the local irregularities.

As it has often been pointed out that the work of running in curves on canal location is unnecessary, and that any curve which best suits the controlling contour is preferable to a circular curve, it may be well to state here the reasons for staking out curves on this work.

1. In order to obtain the correct length of line and thus correct elevation of the grade at any point, it was necessary to make the correct allowance in chainage, due to curvature, and this could only be done by actually staking out the curves on the ground.

2. Since calculations for cross-section of canal, &c., were based on the assumption that the canal bed had a constant fall throughout its length, it was necessary to know the exact length of line in order to arrive at correct conclusions.

3. Although a circular curve may not fit the ground as well as some other curve, yet a circular curve is the only one which can be readily calculated and staked out on the ground.

4. Although a line projected by curves and tangents may not in some cases fit the ground, such a line will approach closer to the true location than a line composed merely of a series of straight lines, and thus any information taken from the former will be more accurate and satisfactory than if taken from the latter.

As soon as a satisfactory location was plotted, tracings were taken off showing the elements of the curves and the position of the projected line relative to the preliminaries already run. These tracings were taken out into the field when running in the location, and the work checked at various points, by tying with the preliminary lines.

The work of running the location was proceeded with in the same manner as was the preliminary, in that several miles were run at a time and then the party broke up and the centre line cross-sectioned.

It has been already pointed out here that, once over the summit, there would be no difficulty in getting the water to the St. Mary river, and in fact if the water was actually turned loose at the summit, there is no doubt that it would eventually find its way into Boundary creek, and thus the St. Mary river. It would, however, flood a large area of valuable land in its course, and the cost of constructing a canal would probably be cheaper than buying the land. And further, if no effort were made to concentrate the water, the losses by evaporation and seepage would be enormous.

Another difficulty encountered in locating the line from the summit of St. Mary river, arose from the fact that Boundary creek for a short distance of its course flows through the United States. It was decided that, if it could be avoided, the canal should not cross the international boundary line.

The canal was located to follow the small waterway leading from the summit to Boundary creek, and in order that a safe velocity would not be exceeded, two verti-

cal drops were provided for. A traverse of Boundary creek was made and also a survey for a dam on Boundary creek at the northwest quarter, section 11, township 1, range 26, west of the 4th meridian. At this point on the creek the water can be diverted, carried over a summit between Boundary creek and the St. Mary river, and emptied into a coulee which leads into the St. Mary river. Thus an alternative to running the water down Boundary creek is possible.

It will be seen from the plans and profiles of this work that the country through which the canal will have to be built is very rough, and in fact, from the intake on the Belly river to the summit at section 5, township 2, range 26, west of the 4th meridian, the line runs across the drainage of the country, so that there is nothing for it but to cross the various coulees encountered. From the summit to the St. Mary river, however, the line follows the natural drainage of the country, and the work will not be so heavy.

Test pits were dug at intervals along the final location, and although in many places there was evidence at the surface of gravel and rock, only at two points was any rock found. The test pits were dug by contract, the terms of which were as follows:—

1. Pits to be dug at such points along the location of the Belly river diversion canal, as will be found most suitable for obtaining information about the character of the soil in that section.

2. No pit to be dug to a depth exceeding eight feet, and no pit to be dug to a depth less than eight feet unless found necessary.

3. One dollar per foot vertical depth to be the price paid for this work whether the pit is dug to a depth of eight feet or less than eight feet.

4. During the progress of the work the pits must be protected against any possibility of sheep, horses, cattle, &c., falling in, and the contractor must assume all responsibility of accidents of that nature.

5. After the pits have been inspected the contractor must cover them up when necessary, so that no accidents will be possible.

6. The work must be completed on or about August 25, 1912.

It was thought advisable in letting this work to have some written agreement with contractors, and the above terms were signed before the work was started.

In order to ascertain the feasibility of diverting water from the Waterton river to the Belly river, levels were run from the permanent iron bench mark at the dam site on the Belly river at section 4, township 2, range 28, west of the 4th meridian, to a point on the Waterton river at section 8, township 2, range 29, west of the 4th meridian. These levels were also checked back of the B.M. on the Belly river. The elevation of permanent iron bench mark on the dam site at Belly river is 4356·74; elevation of high water mark at Waterton lakes 4158·9; the elevation of the height of land between the Belly and Waterton rivers was found to be 4733·6.

From the above elevations it is plainly impossible to divert water from the Waterton river into the Belly river.

RESERVOIR SURVEY.

After a study had been made of the hydrographic records available it was realized before the party commenced work in the field that if a continuous flow of 500 cubic feet per second was to be maintained throughout the season in the canal, that considerable storage capacity would be required.

It was known that the Glenn lakes, which lie in the United States, are of considerable area, and it is very probable that a large amount of water could be reservoired in these lakes at a low cost. As these lakes, however, were not in Canadian territory, no endeavour was made to determine the feasibility of providing for storage in them.

A reconnaissance, however, was made from the first camp at Mountain View as far south as the international boundary, and this proved that in this reach of the

river, that is between the proposed intake and the international boundary, no feasible reservoir sites exist.

The most feasible site for a reservoir was just above the proposed intake of the canal, and the best site for a dam was also found to be at the proposed intake.

It was not found possible to make sufficiently comprehensive surveys to make a close study of the maximum possible size of this reservoir and the cost, but it was decided to adopt a plan which would build the highest dam possible to suit the natural topography of the ground at a comparatively low cost, and the capacity of this reservoir was taken as the greatest that could be gained. There seems very little doubt that, if this reservoir is not of sufficient capacity, the next step to take would be to arrange for storage rights in the Glenn lakes which lie in the mountains at the head of this stream.

OFFICE WORK.

In making a study of the discharge of the Belly river with regard to storage possibilities, all available data were collected, and curves plotted showing the daily discharge throughout the irrigation season. These hydrographs and also mass curves shown on plates 1-8 distinctly point to the fact that a considerable amount of storage will be necessary in order to maintain a continuous flow of 500 c.f.s. throughout the irrigation season.

Unfortunately only one year's records of the discharge of the Belly river at West's ranch, northeast ¼ of section 5, township 2, range 28, west of the 4th meridian, was available, but four curves representing four years' records were deduced from gaugings made at Standoff, southeast ¼ of section 21, township 6, range 25, west of the 4th meridian, by multiplying these records by a certain constant. This constant was arrived at by plotting hydrographs for both gauging stations for the year 1912. The area of each curve was estimated and the one at West's ranch found to be ·84 of the other. By multiplying the records at Standoff for the previous three years by this constant a very close approximation of the discharge of the Belly river at West's was obtained. A study of these curves show that with a reservoir of 7,710 acre feet capacity, the following alternatives are possible for the different years:—

Year 1909, Plates 1-2—

1. Run, 500 c.f.s. from May 1 to August 9.
   Run, 357 c.f.s. from August 9 to September 30.
2. Run, 500 c.f.s. from May 1 to September 3.
   Run, 'flow of river,' September 3 to September 30.
3. Run, 345 c.f.s. continuous.

Year 1910, Plates 3-4—

1. Run, 500 c.f.s. from May 1 to June 20.
   Run, 326 c.f.s. from June 20 to September 30.
2. Run, 500 c.f.s. from May 1 to July 26.
   Run. 'flow of river,' July 26 to September 30.
3. 273 c.f.s. continuous.

Year 1911, Plates 5-6—

1. Run, 500 second feet continuous.

Year 1912, Plates 7-8—

1. Run, 500 c.f.s. from May 1 to July 29.
   Run, 302 c.f.s. from July 29 to September 30.
2. Run, 500 c.f.s. from May 1 to August 25.
   'Flow of river' from August 25 to September 30.
3. Run, 278 second feet continuous.

It is, therefore, evident that even with the reservoir at West's on section 4, township 2, range 28, west of the 4th meridian, it will not be possible to maintain a continuous flow in average years of 500 c.f.s. For purposes of this report, however, it was decided to figure on a canal of 500 c.f.s. capacity at the intake. This will, when the losses for evaporation and seepage are deducted throughout the canal, deliver a quantity of 445 second feet into the St. Mary river during the greater part of every irrigation season.

From a similarity of situation of the two rivers, the Belly and the St. Mary, with respect to the mountains, the high and low water periods in each occur about the same time, so that the critical or dry period in the St. Mary river, when water is most needed, is the very time when, due to the lack of storage, the canal could not deliver water at its full capacity.

This deficiency may be overcome by turning the water into the canal sometime before the irrigation season commences, and utilizing some of the storage sites on the St. Mary river. Reference is made here to Mr. George G. Anderson's report on the proposed agreement between Canada and the United States for the equitable division and use of water in Alberta, Saskatchewan, and the State of Montana. Mr. Anderson goes into the storage possibilities on the St. Mary river very fully, and no doubt a site for a reservoir could be found.

If a channel is constructed for a given discharge, given side slopes, and a given slope, there will be some proportion between breadth and depth, which will make the sectional area a minimum, thus giving a minimum of excavation. Further, since the resistance to flow depends upon the wetted perimeter, it follows that in a channel with the smallest perimeter the velocity will be the greatest, and thus for a given discharge the cross-section will be a minimum.

With these facts in view it can be proved mathematically that for an ideal section the hydraulic mean depth must be equal to one half the actual depth.

It will be seen that a cross-section designed according to these proportions is altogether too deep to be practical. On the other hand, from a study of various canals it has been found that in order to have a canal that will not deposit silt, a very shallow section is necessary.

It is obvious from a study of these conditions that some intermediate section must be chosen, such that the excavation will not be excessive, and the depth not too great to make the construction impractical.

Cross-Section from Intake to Lee Creek.

Quantity required, 500 c.f.s.

A.—228 sq ft.	N.—·025.
P.—45·3 feet.	C.—79·6.
R.—5·03.	V.—2·18 ft. per sec.
S.—·00015.	Q. 498 c.f.s.

Cross Section of Canal from Lee Creek to Sta. 870 + 00.

Due to losses from Evaporation and seepage the quantity required is 480 c.f.s.

A. 220 sq. ft.	N.—·025.
P.—44·3 ft.	C.—79·5.
R.—4·96.	V.—2·17 ft. per sec.
S.—·00015.	Q.—478 c.f.s.

Cross Section of Canal from the Sta. 870 + 00 to 944 + 00.

Due to losses from evaporation and seepage the quantity required is 480 c.f.s.

A.—167·5 sq. ft.	N.—·025.
P.—44·04 ft.	C.—75·0
R.—3·8.	V.—2·92 ft. per sec.
S.—·0004.	Q.—490 c.f.s.

NOTE.—A considerable amount of water will at times have to be taken care of by this section of the canal, as it practically follows the main watercourse from the summit to Boundary creek, so that a section to carry 490 c.f.s. was taken, although 480 c.f.s. is the amount that will actually come down the canal.

Cross-Section of Canal for Boundary from Sta. 944 + 00 to Sta. 1291 + 00, Point 'A.'

Since there are no records of the flood discharge on Boundary creek, 100 c.f.s. is assumed to be a safe allowance.

Losses from evaporation and seepage to Boundary creek, 40 c.f.s.

Total quantity to be provided for, 560 c.f.s.

A.—132 sq ft. C.—71·8.
P.—41·42 ft. N.—·025.
R.—3·19. V.—4·26.
S.—·0011. Q.—561 c.f.s.

Cross-Section of Canal for Alternative Line from Boundary Creek to the St. Mary River.

Total quantity to be provided for, 461 c.f.s.

A.—216 sq. ft. C.—79·5.
P.—43·8 ft. N.—·025.
R.—4·92. V.—2·16 ft. per sec.
S.—·00015. Q.—465 c.f.s.

BELLY-ST. MARY RIVER DIVERSION CANAL—TOTAL ESTIMATE OF COST OF CONSTRUCTION.

Estimate of dam and reservoir at West's ranch.

Sections 4, 5, 32 and 33, township 2, range 28, west of the 4th meridian.

Earth dam and concrete spillway.

Description.	Quantity.	Price.	Cost.
		$ cts.	$
Earth embankment	130,955 cu. yds.	0 25	32,738
Concrete spillway	27,445 "	10 00	274,450
" "	3,441 "	10 00	34,410
Total			341,598

Head gates.

Concrete piers	257.3 cu. yds.	10 00	2,573
Gates			600
Rip rap			160
Total			3,333
Damages to land	700 ac	30 00	21,000
Total cost			365,931

Mile (1) Sta. 0+00—52+80.

Description.	Quantity.	Price.	Cost.
		$ cts.	$
Excavation	55,239 cu.yds.	0 20	11,048
Over haul	11,000 "	0 01	110
Right of way	18.2 ac.	20 00	364
Fencing			340
Total			11,862

Mile (2) Sta. 52+80—105+60.

Description.	Quantity.	Price.	Cost.
Excavation	54,238 cu.yds.	0 20	10,848
Borrow	2,600 "	0 25	650
Overhaul	4,100 "	0 01	41
Road crossing			400
Fencing			247
Right-of-way	13.8 ac.	20 00	276
Total			12,462

Note.—Quantities figured for original location.

Mile (3) Sta. 105+60—158+40.

Description.	Quantity.	Price.	Cost.
Excavation	40,546 cu.yds.	0 20	8,110
Borrow	17,500 "	0 25	4,375
Overhaul	1,000 "	0 01	10
Right-of-way	18.2 ac.	20 00	364
Fencing			340
Total			13,199

Mile (4) Sta. 158+40—211+20.

Description.	Quantity.	Price.	Cost.
Excavation	44,429 cu.yds.	0 20	8,886
Overhaul	14,900 "	0 01	149
Road crossing			400
Right-of-way	18.2 ac.	20 00	364
Fencing			340
Flume and trestle	1,070 ft.		11,566
Total			21,705

Mile (5) Sta. 211+20—264+00.

Description.	Quantity.	Price.	Cost.
Excavation	46,406 cu.yds.	.20	9,282
Borrow	8,800 " "	.25	2,200
Road crossing			400
Right-of-way	18·2 acres.	20.00	364
Fencing			340
Flume & trestle	470 feet.		5,001
Total			17,587

Mile (6) Sta. 264+00—316+80.

Description.	Quantity.	Price.	Total.
		$ cts.	$
Excavation	47,733 cu. yds.	.20	9,547
Borrow	12,700 " "	.25	3,175
Overhaul	11,955 " "	.01	120
Road crossing			400
Right-of-way	18·2 acres.	20.00	364
Fencing			340
Total			13,946

Mile (7) Sta. 316+80—369+60.

Excavation	65,797 cu. yds.	.20	13,160
Overhaul	15,795 " "	.01	158
Road crossing			400
Right-of-way	18·2 acres.	20·00	364
Fencing			340
Flume & trestle	360 feet.		5,078
Total			19,500

Mile (8) Sta. 369+60—422+40.

Excavation	46,442 cu. yds.	.20	9,289
Borrow	7,900 " "	.25	1,975
Overhaul	1,875 " "	.01	19
Right-of-way	18·2 acres.	20.00	364
Fencing			340
Flume & trestle	535 feet.		6,431
Road crossing			400
Total			18,818

Mile (9) Sta. 422+40—475+20.

Excavation	26,929 cu. yds.	.20	5,386
Dam & waste gate			2,000
Right-of-way	67·6 acres.	25.00	1,690
Fencing			193
Head Gate			500
Total			9,769

Mile (10) Sta. 475+20—528+00.

Excavation	32,392 cu. yds.	.20	6,479
Overhaul	17,160 " "	.01	172
Road crossing			400
Fencing			381
Right-of-way	73 acres.	25.00	1,825
Total			9,257

Mile (11) Sta. 528+00—580+80.

Description.	Quantity.	Price.	Total.
		$ cts.	$
Excavation	76,306 cu.yds.	.20	15,260
Right-of-way	18·2 acres.	25.00	455
Fencing			340
Road crossing			400
Siphon & Excavation	1470 feet.	25.30	37,191
Flume & trestle	480 "		5,694
Total			59,340

Mile (12) Sta. 580+80-633+60.

Excavation, cu. yds	53,149	.20	10,630
Overhaul	1,250	.01	13
Road crossing			400
Right-of-way	18·2 ac.	25.00	455
Fencing			340
Flume and trestle	245 ft.		2,758
Flume and trestle	215 "		2,782
Total			17,378

Mile (13) Sta. 633+60-686+40.

Excavation, cu. yds	69,903	.20	13,981
Borrow	5,000	.25	1,250
Overhaul	2,000	.01	20
Road crossing			400
Right-of-way	18 2 ac.	20.00	364
Tunnel	350 ft.	40.00	14,000
Fencing			340
Total			30,355

Mile (14) Sta. 686+40-739+20.

Excavation, cu. yds	69,777	.20	13,955
Borrow	2,000	.25	500
Overhaul	4,000	.01	40
Right-of-way	18·2 ac.	20.00	364
Fencing			340
Flume	650 ft.		5,688
Total			20,887

Mile (15) Sta. 739+20-792+00.

Excavation, cu. yds	158,816	·20	31,764
Road crossing			400
Right-of-way	18·2 ac.	20.00	364
Fencing			340
Total			32,868

Mile (16) Sta. 792+00–844+80.

Description.	Quantity.	Price	Cost.
		$ cts.	$
Excavation, cu. yds	55,219	.25	13,805
Road crossing			400
Right-of-way	18·2 ac.	20.00	364
Fencing			340
Total			14,909

Mile (17) Sta. 844+80–897+60.

Excavation, cu. yds	34,217	.25	8,555
Road crossing			420
Right-of-way	18·2 ac.	20.00	364
Fencing			340
Total			9,679

Mile (18) Sta. 897+60–950+40.

Excavation, cu. yds	59,741	.25	14,935
Road crossing			420
Right-of-way	18·2 ac.	20.00	364
Drops, (10 ft. vertical)	2	1960.00	3,920
Fencing			340
Total			19,979

Mile (19) Sta. 950+40—1003+20.

Excavation	38,654 cu. yds.	25	9,663
Right-of-way	18·2 ac.	30 00	546
Fencing			340
Total			$ 10,549

Mile (20) Sta. 1003+20—1056+00.

Excavation	39,791 cu. yds	25	9,948
Road crossing	2	420 00	840
Right-of-way	18·2 ac.	30 00	546
Fencing			340
Total			$ 11,674

Mile (21) Sta. 1056+00—1108+80.

Excavation	40,034 cu. yds	25	10,008
Right-of-way	18·2 ac.	30 00	546
Fencing			340
Total			$ 10,894

Mile (22) Sta. 1108+80 Point "L" — Sta. 1287+66 "A".

Description.	Quentity.	Price.	Total.
		$ cts.	$
Excavation	5,293 cu. yds.	25	1,323
Right-of-way	19·5 ac.	30 00	585
Fencing			364
Total			$ 2,272

From this point "A" the water runs down Boundary creek channel without any improvement.
Estimate of alternative line from Boundary creek to St. Mary river.

Miles (23—24—25) Sta. 1291+40—Sta. 1465+00.

Excavation	173,297 cu. yds.	20	34,659
Drops (10 ft. vertical.)	1		1,960
Rip Rap	1,460 " "	1 50	2,190
Dam and Waste way			2,000
Fencing			2,280
Road crossings	6	400 00	2.400
Right-of-way	224·5 ac.	20 00	1,490
Total			$ 49,979

Total cost of construction for canal by Boundary creek to St. Mary river	754,820 00
Engineering and contingencies, 10%	75,482 00
Total	$ 830,302 00
Total cost of construction for canal by alternative line from Boundary creek to St. Mary river	804,799 00
Engineering and contingencies, 10%	80,480 00
Total	$ 885,279 00

NOTE.—The estimated cost of $830,962 is for the first 22 miles of location as shown on the key plan down to point A, and from this point the water is allowed to flow down the channel of Boundary creek into the St. Mary river. This course would take the water through the United States for between one and two miles just before reaching the river.

The estimated cost of $885,939 is for the alternative route, 27 miles in length, as shown on the key plan. This route keeps the water entirely within Canadian territory.

CONCLUSION.

It has already been stated in this report that no attempt was made to go into exact details of structures which will be required. An effort has been made, however, to allow a sufficient amount in the estimate for fairly permanent structures throughout the work.

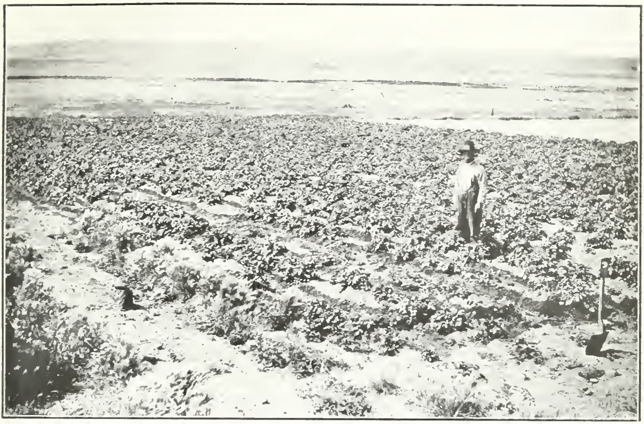
Any revision of the location will be along the lines of getting a better balance of cut and fill, thus reducing the waste and borrow. Such a revision would tend to reduce the cost of earth work.

It will be seen from the estimate that a large proportion of the total cost of the work is for the dam at West's ranch, northwest ¼ of section 4, township 2, range 28, west of the 4th meridian. The dam figured for this estimate was designed with the assumption that a solid foundation existed. No borings were made at the proposed site, and it is impossible to state definitely whether rock exists or not until this work has been done. There is some evidence of a solid foundation, but should it happen that no solid rock exists, the estimate for a dam will be very much in error.

Respectfully submitted,

B. RUSSELL,
Inspecting Engineer.

Falls on the Pipestone River.

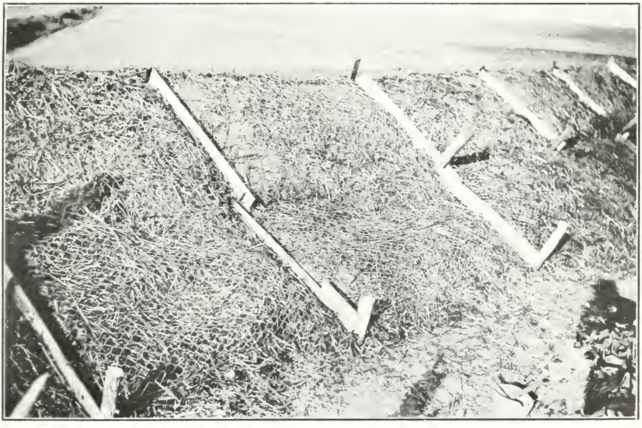


Irrigated potatoes of Angus McKinnon.

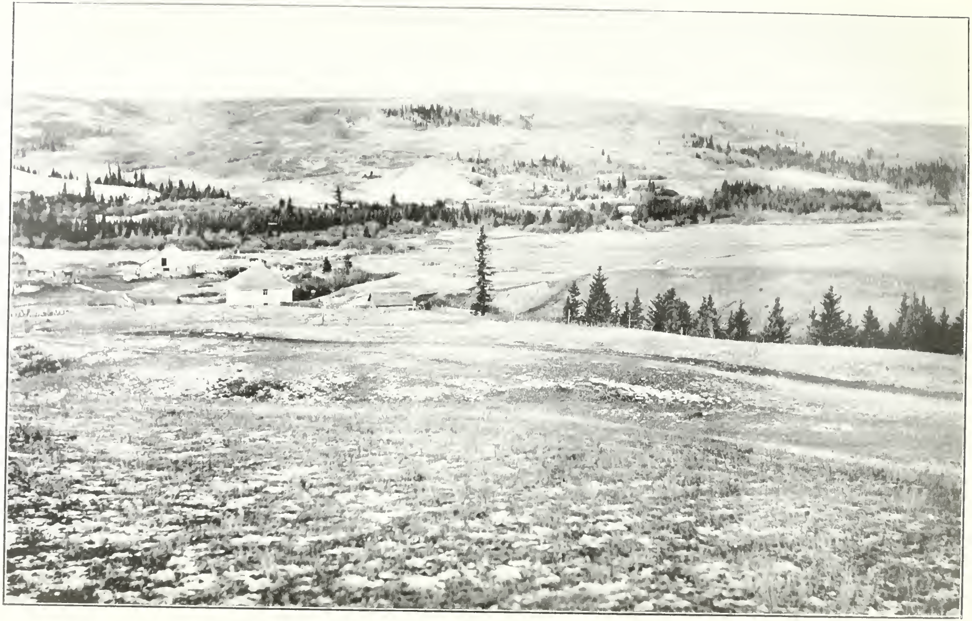
Settlers at Battle Creek en route Wyoming to Peace River.

Oats on E. R. Nash's irrigated land

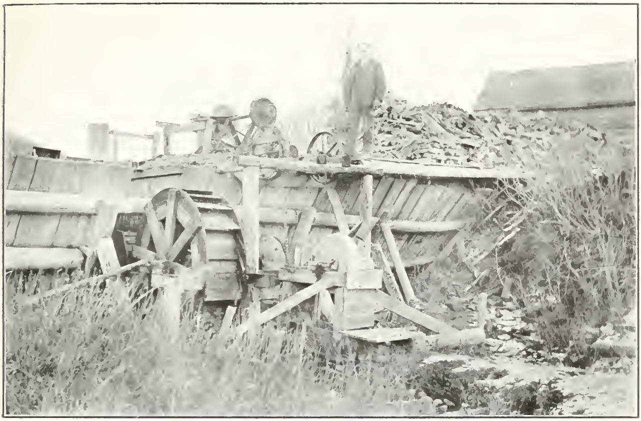
Sheep above Martin's reservoir on Boxelder Creek.



Section of Martin's dam showing facing of straw and chicken wire.

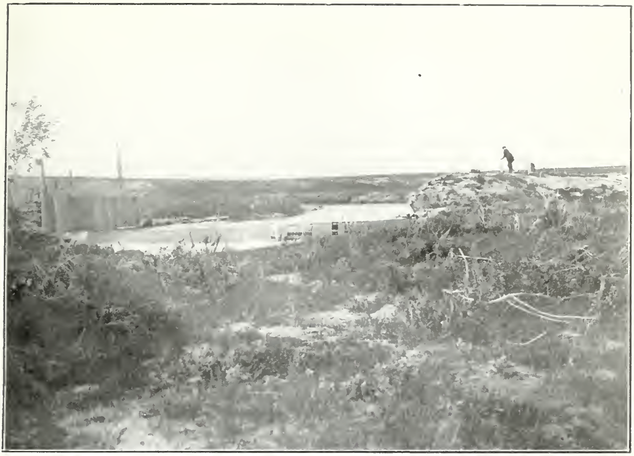


Battle Creek Valley, Fort-Walsh.



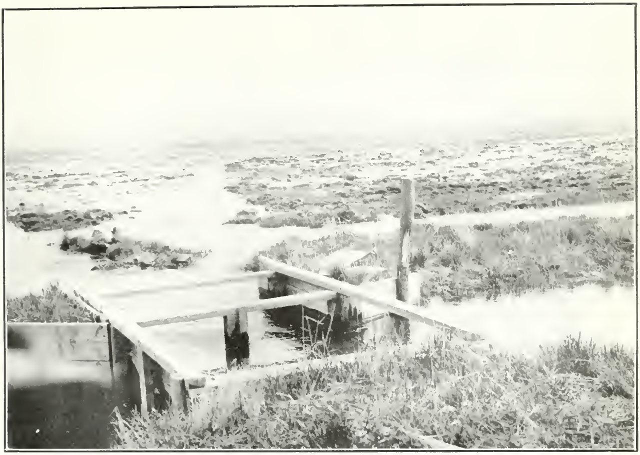
Water Wheel at Wood & Anderson's, Fort-Walsh.

Enright and Strong's irrigated garden.

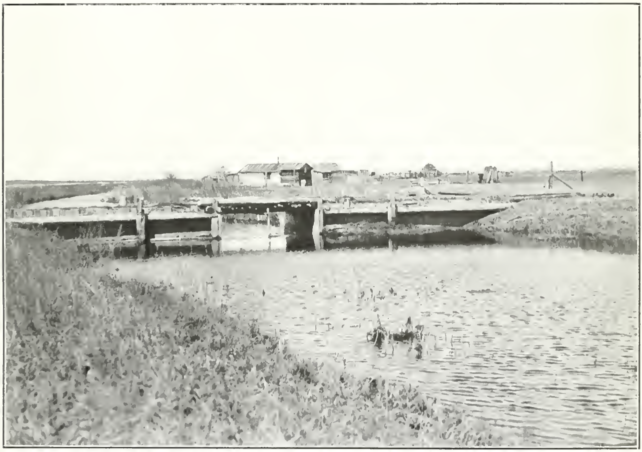


Mrs. L. E. Richardson's dam, Battle Creek.

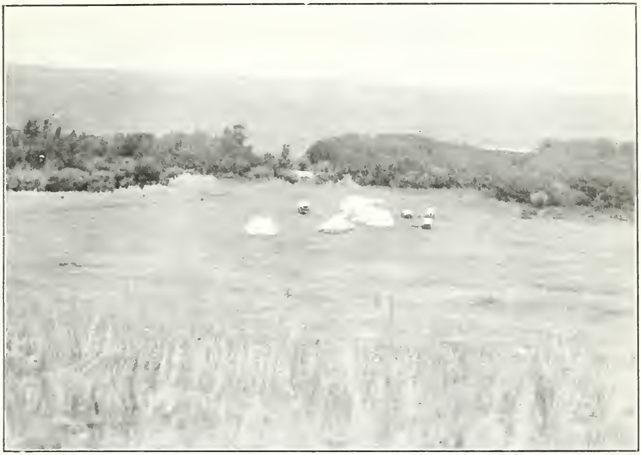
Dr. Smith's Alfalfa field.



Irrigation by flooding, G. A. Gaff's scheme,



D. Drinnan's dam, upper side.



M. H. French's irrigation inspection party, Southern Saskatchewan.

Outlet of Mile-Wide Flume.

25—1914—vii—24

View of Belly River just above dam site, West's ranch.

I. H. Williams' rye cut as green feed off dry land.

25—1914—vii—25

Plate I.

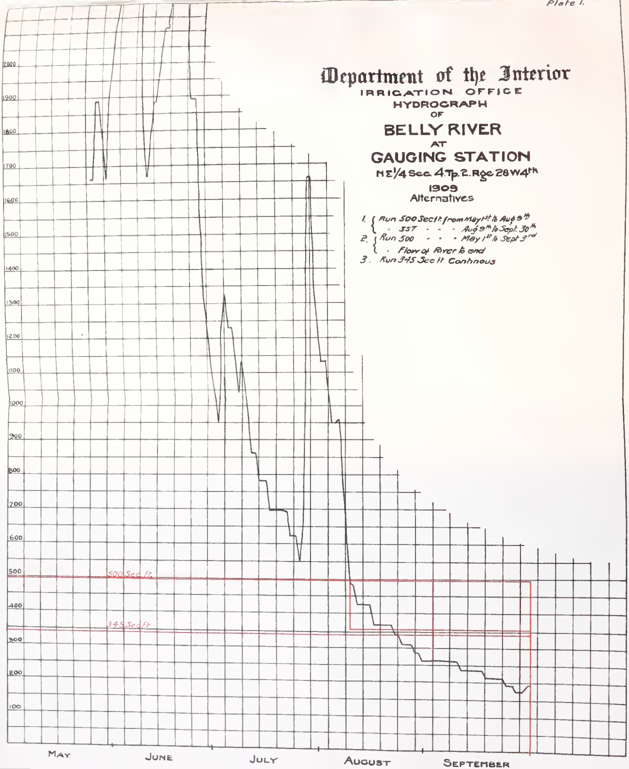
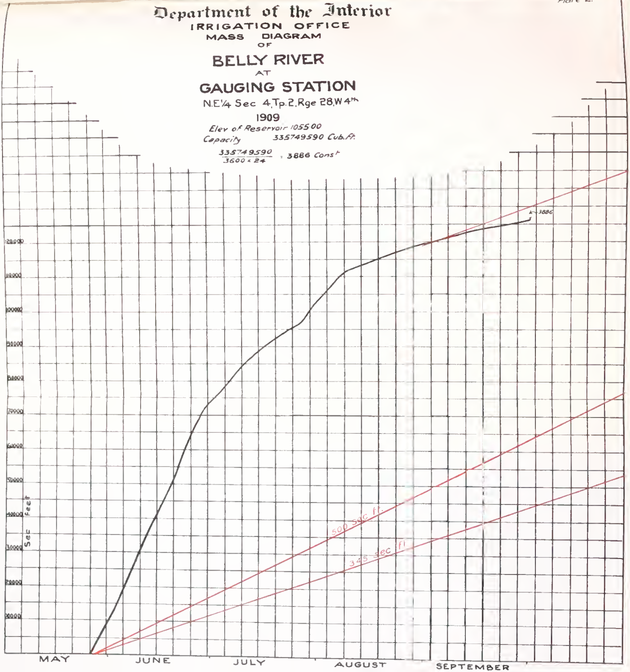

Department of the Interior
IRRIGATION OFFICE
HYDROGRAPH
OF
BELLY RIVER
AT
GAUGING STATION
NE1/4 Sec. 4 Tp. 2. Rge 28 W4th
1909
Alternatives
1. Run 500 Sec ft. from May 1st to Aug 9th
" 357 " " Aug 9th to Sept. 30th
2. Run 500 " " May 1st to Sept 3rd
" Flow of River to end
3. Run 345 Sec ft Continous
500 Sec ft.
345 Sec ft
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
MAY
JUNE
JULY
AUGUST
SEPTEMBER

Plate 2.


Department of the Interior
IRRIGATION OFFICE
MASS DIAGRAM
OF
BELLY RIVER
AT
GAUGING STATION
N.E¼ Sec 4, Tp.2, Rge 28, W 4th
1909
Elev of Reservoir 1055.00
Capacity 335749590 Cub.Ft.
335749590 / 3600 × 24 = 3886 Const
3886
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
Sec Feet
500 sec ft.
345 sec ft
MAY
JUNE
JULY
AUGUST
SEPTEMBER

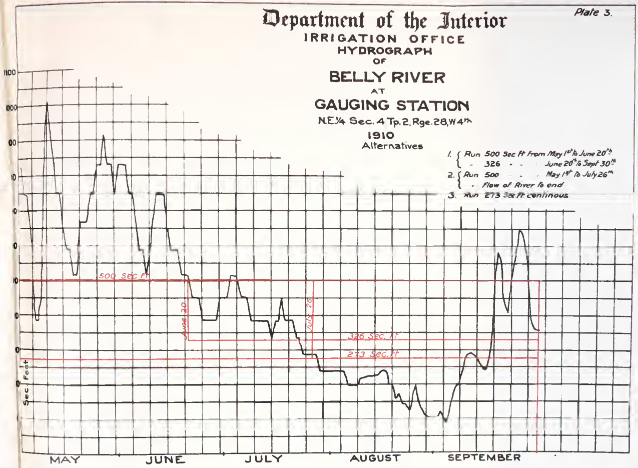


Plate 3.
Department of the Interior
IRRIGATION OFFICE
HYDROGRAPH
OF
BELLY RIVER
AT
GAUGING STATION
N.E.¼ Sec. 4 Tp. 2, Rge. 28, W 4th
1910
Alternatives
1. { Run 500 Sec Ft from May 1st to June 20th
" 326 - - June 20th to Sept 30th
2. { Run 500 - - May 1st to July 26th
" Flow of River to end
3. Run 273 Sec Ft continous
500 Sec Ft
June 20
July 26
326 Sec. Ft
273 Sec. Ft
1100
1000
Sec. Feet
MAY
JUNE
JULY
AUGUST
SEPTEMBER

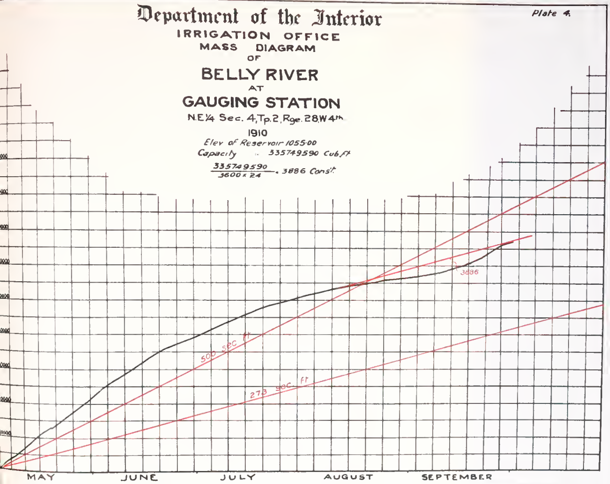
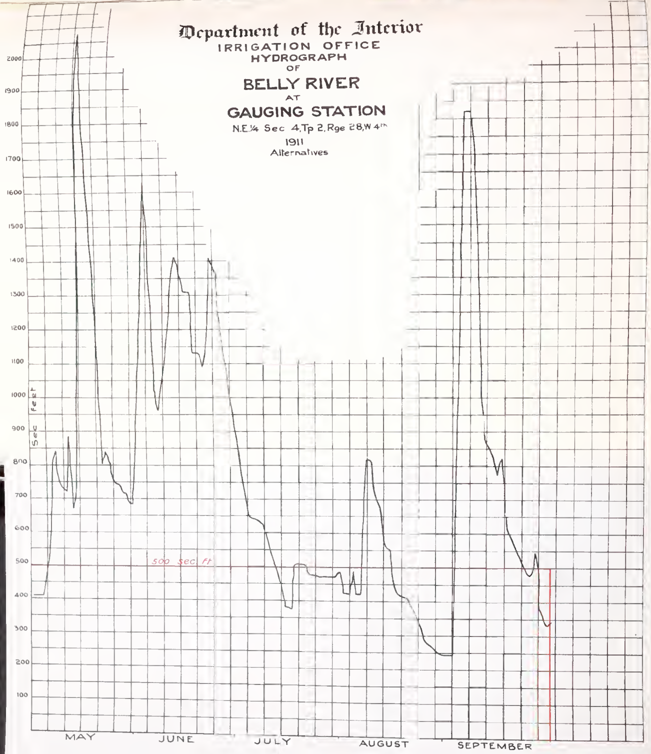


Plate 4.
Department of the Interior
IRRIGATION OFFICE
MASS DIAGRAM
OF
BELLY RIVER
AT
GAUGING STATION
N.E.¼ Sec. 4, Tp. 2, Rge. 28, W 4th
1910
Elev of Reservoir 1055.00
Capacity " 335749590 Cub ft
335749590 / 3600 x 24 = 3886 Cons't
3886
500 sec ft
273 sec ft
MAY
JUNE
JULY
AUGUST
SEPTEMBER


Department of the Interior
IRRIGATION OFFICE
HYDROGRAPH
OF
BELLY RIVER
AT
GAUGING STATION
N.E.¼ Sec 4, Tp 2, Rge 28, W 4th
1911
Alternatives
Sec Feet
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
500 Sec. Ft.
MAY
JUNE
JULY
AUGUST
SEPTEMBER

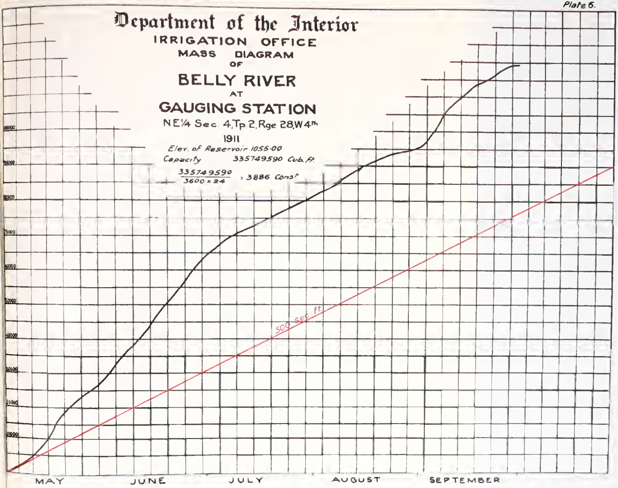
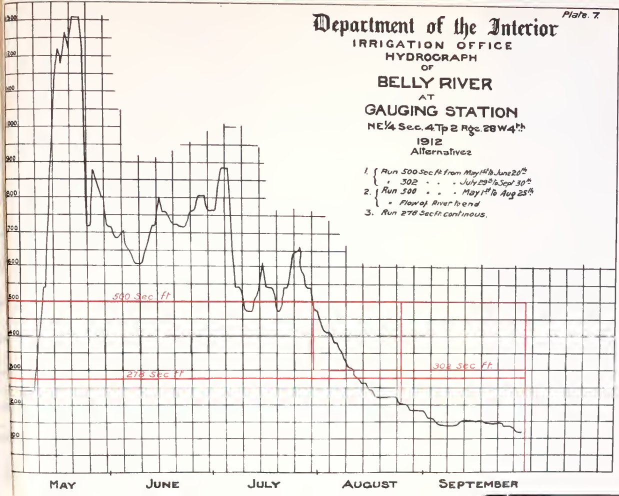

Department of the Interior
IRRIGATION OFFICE
MASS DIAGRAM
OF
BELLY RIVER
AT
GAUGING STATION
NE¼ Sec. 4, Tp 2, Rge 28, W 4th
1911
Elev. of Reservoir 1055·00
Capacity 335749590 Cub. Ft.
$\frac{335749590}{3600 \times 24} = 3886$ Const
500 sec. ft.
70000
60000
50000
40000
30000
20000
10000
MAY
JUNE
JULY
AUGUST
SEPTEMBER

Plate. 7



Department of the Interior
IRRIGATION OFFICE
HYDROGRAPH
OF
BELLY RIVER
AT
GAUGING STATION
NE¼ Sec. 4 Tp 2 Rge. 28 W 4th.
1912
Alternatives
1. Run 500 Sec ft from May 1st to June 20th
" 302 " " " July 29th to Sept 30th
2. Run 500 " " " May 1st to Aug 25th
" Flow of River to end
3. Run 278 Sec ft. continous.
500 Sec. ft
278 Sec. ft
302 Sec. ft.
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
MAY
JUNE
JULY
AUGUST
SEPTEMBER

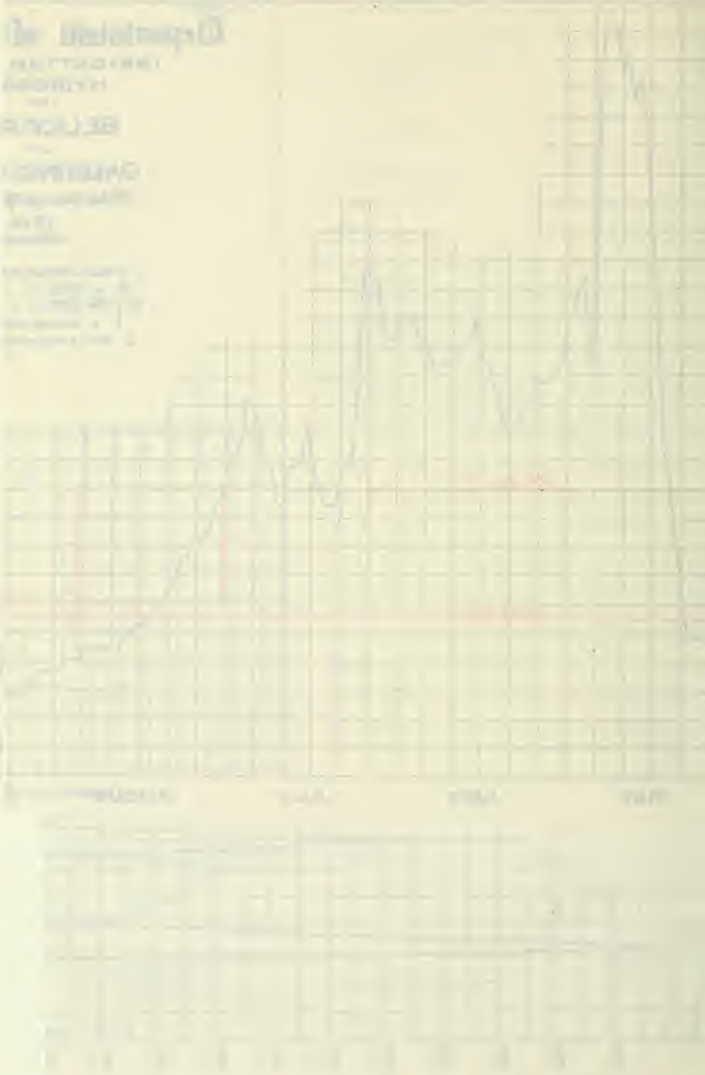
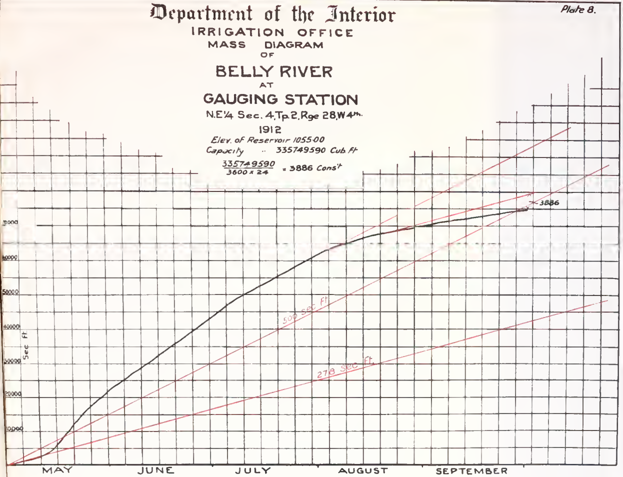


Plate 8.


Department of the Interior
IRRIGATION OFFICE
MASS DIAGRAM
OF
BELLY RIVER
AT
GAUGING STATION
N.E¼ Sec. 4, Tp. 2, Rge 28, W 4th.
1912
Elev. of Reservoir 1055.00
Capacity .. 335749590 Cub. Ft
335749590 / 3600 x 24 = 3886 Cons't
3886
500 sec ft
278 sec ft
Sec Ft
60000
50000
40000
30000
20000
10000
MAY
JUNE
JULY
AUGUST
SEPTEMBER

REPORT ON STREAM MEASUREMENTS, BY P. M. SAUDER, CHIEF HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 31, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg leave to submit the following brief report on the stream measurement work during the past year.

SCOPE OF WORK.

The chief features of the stream measurement work are the collection of data relating to the flow of the surface waters and a study of the conditions affecting this flow. Information is also collected concerning the river profiles, duration and magnitude of floods, irrigation, water-power, storage, seepage, &c., which may be of use in hydrographic studies.

This information is obtained by a series of observations at regular gauging stations which are established at various points. The selection of sites for these gauging stations and their maintenance depends largely on the physical features and needs of the locality. If water is to be used for irrigation purposes the summer flow receives special attention; where it is required for power purposes it becomes necessary to determine the minimum flow; if water is to be stored information is obtained regarding the maximum flow. In all cases the duration of the different stages of the stream is recorded. Throughout the country gauging stations are maintained for general statistical purposes, to show conditions existing through long periods. They are also used as primary stations, and their records in connection with short series of measurements will serve as bases for estimating the flow at other points in the drainage basin.

In the spring of 1912 field operations were commenced with one hundred and thirty-two (132) regular gauging stations on the various streams in Alberta and Saskatchewan, and thirty (30) on irrigation ditches, and at present the regimen of flow is being studied at one hundred and thirty-nine (139) regular gauging stations on streams and forty (40) on irrigation ditches. Winter records, which are so valuable for power investigations and municipal water supplies, have been given special attention latterly and records have been secured on almost all the important streams in the two provinces during the past winter.

ORGANIZATION.

The methods of collecting the data were similar to those of previous years. Local residents were engaged to observe the gauge height at regular gauging stations. These observations were recorded in a book supplied by this office and at the end of each week the observer copied the week's records on a postal card, which he sent to this

office by the first convenient mail. The district hydrographers made regular visits to the gauging stations, usually once in every three weeks. On these visits they examined the observer's records, made discharge measurements and collected such information and data as would be of use in making estimates of the daily flow at the station. The results of the gaugings were transmitted by a postal card to this office. At the close of the open season some of the engineers returned to the office and assisted in the final computations and estimates of run-off. Gauge height area, gauge height mean velocity, and gauge height discharge curves were plotted and rating tables constructed. Tables of discharge measurements, daily gauge height and discharge, and monthly discharge were also compiled. These records are being recopied and will be embodied in the fourth annual report of the Progress of Stream Measurements, which is being submitted separately.

The organization in 1912 was very similar to that of the previous years. The regular staff consisted of the chief hydrographer, ten assistant engineers, one recorder, one computer and one clerk. In order to overtake arrears of work, three junior engineers were also employed temporarily during the past four months. The territory was divided for administrative purposes, into nine districts, viz., Banff, Calgary, Macleod, Cardston, Milk River, Western Cypress Hills, Eastern Cypress Hills, Moosejaw and Battleford. In each district there was an engineer and while in the field he had an assistant, and was equipped with the necessary gauging and surveying instruments. In the Banff, Calgary, Macleod, Moosejaw and Battleford districts, the engineers travelled by train or hired livery, and stopped at hotels and stopping houses, while in the other districts they were supplied with a team, light wagon and light camping outfit. The tenth engineer was employed at rating meters and office work during the summer.

As winter records are of no value on a great many of the smaller streams, the number of gauging stations maintained during the winter months was much less than during the summer, and by rearranging the districts five engineers were able to do all the field work during the winter. The other five engineers and the three juniors have compiled the records for the annual report.

BANFF DISTRICT.

This district included the following regular gauging stations:—

Stream.	Location.	Date established.
Bow river	S.E. 28-28-16-5*	July 18, 1910
"	N.E. 35-25-12-5	May 25, 1909
"	N.W. 32-24-8-5	Feb. 1, 1912
Cascade river	S.E. 19-26-11-5	Aug. 16, 1911
Forty-mile creek	S.W. 2-26-12-5	July 31, 1912
Ghost river	N.E. 23-26-6-5	Aug. 17, 1911
Jumpingpound creek	Section 30-24-4-5	May 7, 1908
Kananaskis river	N.E. 33-24-8-5	Aug. 31, 1911
Pipestone river	S.W. 27-28-16-5	Aug. 31, 1911
Spray river	S.W. 25-25-12-5	July 15, 1910

* This station was originally on N.E. 28-28-16-5 but was moved to its present position on Aug. 31, 1911.

As work in this district has been carried on for some time, and several new stations had been established after a thorough reconnaissance in 1911, very few changes were made in the district during 1912. In a few cases the conditions have

been so unfavourable that gauge readings could not be obtained all winter, but in almost every case discharge measurements have been made regularly at intervals of about two weeks during the whole year at all of the above stations excepting Forty-mile creek, which was not established until July 31, 1912, and Jumpingpound creek, which was not included during the winter months.

During the year special gaugings were made of Baker creek (S.E. 32-27-15-5), Bath creek (N.E. 32-28-16-5), Beaupré creek (S.E. 15-26-5-5), Big Hill creek (S.W. 10-26-4-5), Grand Valley creek (S.W. 24-26-5-5), Healey creek (S.W. 29-25-12-5), Horse creek (N.E. 8-26-4-5), Johnson creek (S.W. 26-26-14-5), Louise creek (N.E. 20-28-16-5), and Spencer creek (S.E. 18-26-5-5) whenever possible.

Owing to the comparatively low flow of Bow river during the winter months, the Calgary Power and Transmission Company, which has a power plant in operation at Horseshoe falls and is building another plant at Kananaskis falls, found it necessary to store water to tide them over this period, and last spring built a dam on Cascade river near the mouth of Devils creek to increase the storage capacity of Lake Minnewanka. The dam was completed before the high water period in June and the reservoir was, therefore, filled last summer and emptied during the past winter. As this dam backs water up Devils creek the gauging station on this stream had to be abandoned, and it must be borne in mind when using the records of flow of Cascade and Bow rivers below Lake Minnewanka reservoir, that after the first of June, 1912, the flow is affected by the operation of this reservoir and the records do not represent the true natural flow of the stream.

The town of Banff takes its domestic water supply from Forty-mile creek and as its requirements are gradually increasing it was thought advisable to take records of the flow of this stream. It is, however, impossible to get an observer above the intake of the waterworks and the station had to be established below the intake. The records, therefore, only represent the surplus flow which is not used by the town, and the consumption of the town has to be added to obtain the total natural flow of the stream.

Bath creek is an important tributary of Bow river, but no regular station has been established on it, as it has been impossible in the past to secure an observer. This difficulty may not exist in future, and if so, a regular gauging station will be established.

Records will also be taken in future of the flow of Louise creek, which is used by the Canadian Pacific Railway Company to develop power for use at the Lake Louise Chalet.

The dam being constructed by the Calgary Power and Transmission Company at Kananaskis falls will flood out the present gauging station on Kananaskis river, and it will soon have to be relocated further upstream.

Further power development on Bow river depends very largely on the creation of storage reservoirs, to conserve flood water for use during the winter months, and during 1912 the Water Power Branch continued and completed its investigations of the upper regions of Bow river drainage basin. Whether any new stations are established in this district or any of the present ones are abandoned will depend largely on the report of the Water Power Branch, and it is, therefore, awaited with much interest.

H. C. Ritchie, Grad. S.P.S., was in charge of the field work in the Banff district during the whole of the past year. The final computations were made by F. R. Steinberger, B.E. A report of the field work done by Mr. Ritchie is attached.

CALGARY DISTRICT.

This district includes the following regular gauging stations:

Stream.	Location.	Date Established.
Berry Creek	N.E. 21-23-13-4	May 30, 1911.
Blood Indian Creek	S W. 10-23-8-4	June 26, 1911.
Bow River	N.E. 15-24-1-5	Nov. 25, 1910.
"	Sec. 13-21-19-4	By C.P.R. Co. on Aug. 20, 1909.
Can. Pac. Ry. Co. Canal	N.E. 36-23-1-5	May 9, 1908.
Elbow River	S.W. 14-24-1-5 (1)	May 8, 1908.
Findlay & McDougal Ditch	S.W. 31-18-29-4	June 17, 1911.
Fish Creek	S.W. 26-22-3-5	May 13, 1907.
Highwood River	S.E. 20-18-2-5	July 27, 1912.
"	N.W. 6-19-28-4	May 28, 1908.
"	N.W. 17-20-28-4	October 3, 1911.
Little Bow Ditch	S.W. 6-19-28-4	Aug. 1, 1910.
Nose Creek	N.W. 13-24-1-5	April 24, 1911.
Pekisko Creek	N.W. 8-17-2-5	Oct. 6, 1911.
Sheep River	N.W. 22-20-29-4	May 25, 1908.
N. B. Sheep River	S.W. 12-21-3-5	May 22, 1908.
S. B. "	S.W. 17-20-2-5	May 23, 1908.
Stimson Creek	N.W. 2-17-2-5 (2)	Oct. 6, 1911.

(1) This station was originally on S.E. 15-24-1-5, but was moved to its present position in November, 1911.

(2) This station was originally on N.E. 14-17-2-5, but was moved to its present position on July 4, 1912.

This district is the same as in 1911, except that a regular gauging station has been established on Highwood river above the mouth of Pekisko creek. While this station was established primarily for statistical purposes, its records will probably be of considerable value in determining the possibilities of power development on this stream.

There has been no special development in this district during the past year, but as the canals being constructed by the Canadian Pacific Railway Company, the Alberta Land Company, and the Southern Alberta Land Company, are nearing completion, the value of the records of stream flow becomes more apparent. The first company will no doubt require much more than the average low water flow of Bow river, and the other two depend entirely on the high water and flood discharge of the river for their water supply. Not only is it necessary to know the discharge of the river at these stages but also the duration of each stage. The Southern Alberta Land Company is very fortunate in having a very large reservoir, as it will probably have to divert its water supply for the five irrigating months in less than three months, unless the reservoir can be partly filled in the early spring before the Canadian Pacific Railway Company starts to use water or in the fall. These problems cannot, however, be satisfactorily solved without records of stream flow covering a period of several years, and now that there are nearly five years records of the flow of Bow river at Calgary approximate estimates at least can be made.

In designing a dam it is essential to know the maximum flood discharge of the stream in order to provide the necessary spillway to pass it without injury to the structure or adjoining property. During the past year all available data regarding the floods on Bow river were collected and estimates of the maximum flood discharge at different points were made. The results of this study are given in a separate report.

There have been no floods during recent years and their magnitude is therefore possibly not realized by some civil engineers. I have not actually checked any of the bridge openings, but I am inclined to think that the maximum flood discharge has in some cases been under-estimated and much damage may be done some day.

Miscellaneous gaugings were made of Red Deer river, east branch of Berry creek, Bullpound creek, north branch of Fish creek, south branch of Fish creek, Pine creek, Tongueflag creek, Lineham's spillway at High river and a spring at McMillan's ranch near High river, whenever possible.

Owing to the excessive cost and difficulty of securing accurate records it has been decided to discontinue the gauging stations on Berry and Blood Indian creeks until some new railway line makes it easier and less expensive to reach them.

Winter records were only taken on Elbow and Bow rivers at Calgary and High wood river at High river, the first two stations being included in the Banff district during the winter months and the latter in the Macleod district.

F. R. Burfield, A.M.I.C.E., was in charge of the field work in this district during the past year and made the final computations for the annual report. A report of the field work done by Mr. Burfield is attached.

MACLEOD DISTRICT.

Stream.	Location.	Date Etablished.
Belly river	N.W. 1-9-22-4	Aug. 31, 1911.
Canyon creek	N.E. 14-6-2-5	July 6, 1910.
Cardwell ditch	S.W. 31-8-1-5	July 11, 1912.
Carmichael ditch	S.E. 34-13-29-4	July 22, 1912.
Connelly creek	S.E 36-7-2-5	July 31, 1909.
Cow creek	N.E. 14-8-2-5	May 26, 1910.
Crowsnest river	S.W. 12-8-5-5	July 28, 1910.
" "	N E. 36-7-4-5	July 28, 1910.
" "	N.E. 26-7-2-5	Sept. 7, 1907.
Elton ditch	N.E. 19-8-1-5	July 10, 1912.
Ford ditch	N.E. 25-13-1-5	June 28, 1912.
" "	N.E. 26-13-1-5	June 28, 1912.
Mill creek	S.W. 18 6-1-5	July 7, 1910.
Mosquito creek	N.E. 30-16-28-4	Aug, 1 1908.
Muddypound creek	S.W. 27-11-28-4	July 27, 1908.
Fanton creek	N.W. 20-16-28-4	Aug. 3 1908.
Oldman river	N.E. 34-7-1-5	Sept. 15, 1908.
Oldman river	N.W. 10-9-26-4	July 12, 1910.
Pincher creek	N.E. 22-6-30-4	Aug. 13, 1906.
Riley ditch	S.W. 17-13-2-5	Aug. 1, 1912.
Southfork river	S.E. 2-7-1-5	Aug. 5, 1912.
St. Mary river	N.E. 26-7-22-4	Oct. 13, 1911.
Summit creek	S.W. 12-8-6-5	Feb. 21, 1912.
Todd creek	S.W. 19-8-1-5	Aug. 3, 1909.
Trout creek	S.E. 33-11-28-4	July 7, 1911.
Willow creek	S.E. 26-9-26-4	July 1, 1909.

As this district had been thoroughly reconnoitred during previous years it was not necessary to establish any new stations on rivers or creeks during 1912. As, however, some of the smaller streams in the Crowsnest Pass are being used for domestic and industrial water supplies, it will probably be advisable to establish regular gauging stations on some of these during the coming year.

Special gaugings were made of Blairmore creek (section 10-8-4-5), Fortier's springs (section 17-1-1-5), Gold creek (section 30-7-3-5), Lyon creek (section 26-7-4-5), McGillivray creek (N.E. 7-8-4-5), Nez-perce creek (section 17-8-4-5), Spring creek (N.E. 27-13-29-4), Willow creek (S.W. 36-12-28-4), and York creek (N.W. 34-7-4-5), whenever possible.

Owing to the abundance of coal in this district power is not very expensive and water power has not been developed at all. There are no great power possibilities, but there are good opportunities for developing a small amount of power very cheaply. One very serious drawback to water power development is the absence of suitable sites for reservoirs to store water to augment the winter flow.

Irrigation is not generally required in this district and the development in that line is therefore not very great.

The gauges on the Riley and Ford ditches were established by Charles Chambers, inspector of irrigation works. As they are a long distance from the railway and are only occasionally in use the district hydrographer did not visit them at all.

Winter records were taken of Belly river, Crownest river (three stations), Oldman river (two stations), South Fork river, St. Mary river, and Summit creek; Belly and St. Mary rivers were included in the Cardston district during the winter months.

N. M. Sutherland, Grad. R.M.C., was in charge of the field work in this district until May 6, when he was transferred to the survey party locating a canal from Belly river to the St. Mary river, and A. W. P. Lowrie, B.Sc., was placed in charge. Mr. Lowrie returned to the office about the end of November to make the final computations for the annual report. and H. O. Brown, B.Sc., has been in charge of the field work since that date. Reports of the field work done by Messrs. Lowrie and Brown are attached.

CARDSTON DISTRICT.

This district includes the following regular gauging stations:—

Stream.	Location.	Date Established.
Belly river	N.E. 5-2-28-4	Nov. 1, 1911
"	S.E. 21-6.25-4	May 27, 1909
A. R. & I. canal	S.E. 21-2-24-4	July 26, 1910
Christianson ditch	S.E. 12-3-28-4	Sept. 14, 1911
Crooked creek	S.W. 22-2-29-4	Sept. 15, 1909
Fiddler ditch	S.E. 19-1-26-4	Sept. 13, 1911
Lee creek	N.W. 10-3-25-4	June 28, 1909
Mami creek	S.E. 19-2-27-4	Aug. 13, 1909
North Branch Milk river	N.E. 13-1-23-4	July 21, 1909
" "	N.E. 18-2-20-4	July 17, 1909
Rolph creek	S.E. 21-2-24-4	May 17, 1911
St. Mary river	Sec. 25-1-25-4	By A. R. & I. Co. in 1905.
Waterton river	N.E. 8-2-29-4	Aug. 26, 1908

As Mami creek is of little importance no gauge observer was engaged, but discharge measurements were made regularly on each round of the hydrographer during the open-water period. No gauge observer could be obtained for the North branch of Milk river on the northeast ¼ section 18, township 2, range 20, west of the 4th meridian, but gaugings were made by the hydrographer whenever possible.

Special discharge measurements were also made of St. Mary river (N.W. 11-3-25-4), Boundary creek (S.E. 11-1-26-4), Cottonwood creek (S.E. 21-2-29-4), Blakiston brook (N.E. 30-1-29-4), Oil creek (N.W. 23-1-30-4), Yarrow creek (S.W. 15-4-29-4), Drywood river (N.W. 17-4-29-4), and Dryfork creek (N.W. 36-4-30-4), whenever possible.

In August last an arrangement was made with the United States Geological Survey by which regular gauging stations on St. Mary and Milk rivers would in future be maintained jointly, each country bearing half the cost of construction and maintenance. To get more accurate and satisfactory records it was decided to re-locate the stations at the best sites near the international boundary and install automatic recording gauges. In August the Commissioner of Irrigation of Canada and W. A. Lamb, District Engineer, United States Geological Survey met at Helena, Montana, went over the ground together, and decided upon the location, design and shelter for each gauge. The site chosen on St. Mary river is on the southwest ¼, section 25, township

1, range 25, west of the 4th meridian, and in October V. Meek of this department constructed a reinforced concrete shelter for the automatic recording gauge. A Friez water stage register has been purchased for this station and will be installed at an early date.

The site chosen on the north branch of Milk river is on the northeast ¼, section 11, township 1, range 21, west of the 4th meridian, and last October V. Meek constructed a wooden shelter for the automatic recording gauge. A Stevens continuous water stage register has been purchased for this station and will be installed at an early date.

Winter records were taken at the regular stations on Belly river, Lee creek, north branch of Milk river (N.E. 13-1-23-4), St. Mary river, and Waterton river; the station on Belly river at Standoff was included in the Macleod district during the winter months.

As there is considerable increase in the flow of Waterton river below the regular gauging station at Waterton Mills a regular gauging station will be established near its mouth as soon as a suitable site can be found.

There are only a few irrigation ditches in this district and the hydrographer therefore makes the necessary inspections. Unless urgent, these are usually made in the late summer or early fall when the streams are low and almost stationary, and need not be gauged as often as usual.

L. J. Gleeson, B.Sc., was in charge of the field work in this district until July 15, when he was transferred to a survey party in Saskatchewan, and V. Meek, B.Sc., was placed in charge. On February 1, Mr. Meek was transferred to the Edmonton district and G. F. Deas has been in charge of the field work since that date. J. E. Degnan and G. R. Elliott, made the final computations of the 1912 records and completed the 1911 records.

A report of the field work done by Mr. Meek is attached.

MILK RIVER.

This district includes the following regular gauging stations:—

Stream.	Location.	Date Established.
Deer creek	S.W. 15-1-12-4	May 26, 1911
Deer creek Cattle Co. ditch	S.W. 36-1-12-4	May 27, 1911
Hooper & Huckvale ditch	S.W. 27-4- 6-4	May 2, 1912
Manyberries creek	S.W. 27-4- 6-4*	June 17, 1910
Milk river	N.E. 21-2-16-4	May 18, 1909
"	S.W. 35-1-13-4	Aug. 2, 1909
"	S.W. 21-2- 8-4	Aug. 5, 1909
"	S.E. 3-1- 5-4	Aug. 7, 1909
North Branch Milk river	S.W. 19-2-18-4	July 15, 1909
South Branch Milk river	N.W. 31-1-18-4	July 14, 1909

* This station was originally on S.E. 3-5-6-4, but was moved to its present position on May 2, 1912.

The number of regular gauging stations in this district is comparatively small but, owing to shifting conditions at every one of them, it is necessary to make frequent gaugings in order to get reliable records, and as the distance between the stations is above the average the hydrographer cannot cover a larger district.

The arrangement with the United States Geological Survey also includes gauging stations on Milk river and the south branch of Milk river in this district. The site chosen on Milk river is on the northeast ¼, section 6, township 37, range 9, east principal meridian, in the State of Montana, and in November last J. E. Degnan, of this

Department, constructed a wooden shelter for the automatic gauge. A Gurley automatic self-winding water stage register has been purchased for this station and will be installed at an early date.

The site chosen on the South branch of Milk river is at Croft's ranch on the Blackfoot Indian Reserve in Montana, and Mr. Lamb, of the United States Geological Survey, is building the shelter and will install a Stevens continuous water stage register at an early date.

It was impossible to secure an observer for the gauge on the North branch of Milk river on the southwest ¼ section 19, township 2, range 18, west of the 4th meridian, but discharge measurements were made at every opportunity.

Special gaugings were made of Red creek (section 18-1-15-4), Police coulee (section 35-1-13-4), Deadhorse coulee (section 4-2-11-4), Miners coulee (section 10-2-11-4), Halfbreed creek (section 28-2-10-4), Beargulch creek (section 19-2-9-4), Kennedy creek (section 3-1-5-4), Ketchum creek (section 21-4-6-4), Canal creek (section 6-4-6-4), South branch of Manyberries creek (section 11-5-6-4), Lost river (township 1-4-4), and Verdigris coulee (section 22-2-14-4), whenever possible.

Winter records were only taken at the gauging station on Milk river on the northeast ¼ section 21, township 2, range 16, west of the 4th meridian, which was included in the Cardston district during the winter months.

In this district also the hydrographer makes inspections of and reports on irrigation works.

J. E. Degnan was in charge of the field work during the past year and also made the final computations for the annual report. He was assisted in the field and office by R. J. Sprigley.

A report of the field work done by J. E. Degnan is attached.

WESTERN CYPRESS HILLS DISTRICT.

This district includes the following regular gauging stations:—

Stream.	Location.	Date Established.
Anderson Ditch	S.W. 23-6-3-4	Sept. 23, 1911.
Battle Creek	N.E. 33-5-29-3	June 3, 1909.
"	N.W. 33-5-27-3 (1)	July 5, 1910.
"	N.E. 3-3-27-3	May 10, 1910.
Bullshead Creek	N.W. 15-9-5-4	Oct. 9, 1911.
Cheeseman Ditch	S.W. 12-8-29-3	June 24, 1911.
Gaff Ditch	S.W. 25-5-29-3	July 11, 1911.
Gap Creek	N.E. 31-11-26 3	May 3, 1910.
"	S.E. 4-10-27-3	April 25, 1910.
Gilchrist Ditch	S.W. 11-5-27-3	Oct. 16, 1911.
Grosventre Creek	S.E. 27-9-4-4	Oct. 10, 1911.
Lindner Ditch	N.W. 10-6-29-3	July 26, 1910.
Lodge Creek	S.E. 12-1-29-3	Aug. 13, 1909.
"	N.E. 36-3-1-4	Aug. 31, 1912.
"	N.W. 10-6-3-4	July 22, 1909.
East Branch Lodge Creek	S.E. 1-7-3-4	Oct. 7, 1911.
East Branch Mackay Creek	N.W. 36-10-1-4	Oct. 13, 1911.
West " "	N.W. 27-10-1-4 (2)	Oct. 12, 1911.
Maple Creek	N.E. 16-11-26-3	May 9, 1908.
"	S.E. 28-11-26-3	May 4, 1910.
Marshall & Gaff Ditch	N.E. 33-5-29-3	July 11, 1911.
McShane Creek	S.W. 3-10-27-3	April 23, 1909.
McKinnon Ditch	N.W. 20-4-26-3	Oct. 20, 1911.
Middle Creek	S.W. 35-5-1-4	June 21, 1910.
"	S.W. 30-5-29-3	July 20, 1909.
"	N.W. 4-2-29-3	June 13, 1910.

(1) This station was originally on the S.W. 2-6-28-3, but was moved to its present position on May 29, 1912.

Stream.	Location.	Date Established.
Oxarart Creek	N.E. 20-6-27-3	June 15, 1909.
Richardson Ditch	S.E. 2-5-27-3	Oct. 14, 1911.
Ross Creek	N.W. 24-9-3-4	Oct. 11, 1911.
Sage Creek	N.E. 9-1-2-4	Aug. 10, 1909.
Six-mile Coulee	S.W. 6-7-28-3	July 4, 1911.
Spangler Ditch	S.W. 6-7-28-3	July 10, 1911.
Starks & Burton Ditch	S.E. 17-11-5-4	Oct. 9, 1911.
Stirling & Nash Ditch	Sec. 22-3-27-3	July 11, 1911.
Ten-mile Creek	S.E. 4-6-29-3	July 21, 1909.
White Ditch	S.W. 1-9-27-3	June 15, 1911.

(2) This station was originally on the S.W. 23-10-2-4, but was moved to its present position on Sept. 12, 1912.

In order to get more complete records of the flow of Lodge creek a new station was established on the northeast ¼, section 36, township 3, range 1, west of the 4th meridian, which is above the larger ditches diverting water from the main branch of Lodge creek. No other changes of importance were made in the district except that the location of one of the gauges on Battle creek had to be changed, as shown above, so that an observer could be secured.

Special gaugings were made of Battle creek (section 16-2-26-3 and N.W. 21-7-29-3), Cypress creek (S.E. 6-9-27-3), Middle creek (N.E. 23-5-30-3 and N.W. 15-3-29-3), McShane creek (N.E. 2-9-27-3), Piegan creek (S.E. 28-7-4-4), and Spring coulee (N.W. 22-6-1-4), whenever possible.

Many of the ditch owners do not realize the value of records of the water used by them, and it has therefore been impossible to get good records on the ditches, but these will gradually improve, for as irrigation increases the irrigator will find the records very useful and will be only too glad to co-operate with the government in taking them.

This district includes a great many regular gauging stations on very small streams, but as every bit of available water will eventually be used for irrigation purposes, records on these are valuable.

While this is a rather large driving district, it can be covered satisfactorily except during the spring time. There is usually quite a large snowfall in the hills during the winter and this usually runs off very quickly when spring opens up and the streams become quite high for a short time. Sometimes rains follow and keep the flow up, but not always, and the irrigators depending on high water and flood discharges of the stream should fill their reservoirs at the first opportunity. The records during early spring are therefore of considerable importance, but as the freshets are of short duration and travelling is difficult at that time it is impossible for one hydrographer to cover the district properly. The hydrographer should also be in the field on or shortly after the middle of March. This has not always been possible, owing to the fact that the fiscal year ends on March 31 and funds were not available. Provision should therefore be made in future estimates so that two hydrographers can be placed in this district during the spring and so that they can start field work about the middle of March.

Winter measurements would be of little value in this district and none have therefore been taken.

G. R. Elliott, B.Sc., was in charge of the field work in this district and made the final computations for the annual report. A report of the field work done by him is attached.

EASTERN CYPRESS HILLS DISTRICT.

This district includes the following regular gauging stations:—

Stream.	Location.	Date established
Axton Ditch	N.E. 23-7-21-3	Aug. 12, 1911.
Bear Creek	S.E. 18-11-23-3	June 22, 1908.
East Branch Bear Creek	S.E. 21-10-23-3	Aug. 18, 1909.
West Branch " "	S.W. 32-10-23-3	Sept. 16, 1909.
Belanger Creek	S.W. 18-7-25-3	June 12, 1909.
" "	S.W. 30-6-25-3	March 31, 1912.
East Branch Beveridge Ditch	N.E. 7-10-24-3	June 9, 1911.
West Branch " "	N.E. 18-10-24-3	June 5, 1911.
Bone Creek	N.W. 34-8-22-3	July 2, 1908.
Braniff Ditch	S.E. 30-11-23-3	July 22, 1911.
Bridge Creek	N.E. 11-11-22-3	July 29, 1909.
" "	S.E. 33-10-22-3	April 29, 1911.
Cross Ditch	N.W. 15-7-22-3	Sept. 9, 1911.
Davis Creek	N.E. 29-6-25-3	May 24, 1909.
Dimmock Ditch	S.E. 16-11-21-3	July 29, 1912.
Fairwell Creek	N.W. 30-6-24-3	June 10, 1909.
Fearon & Moorehead Ditch	N.E. 29-10-22-3	July 6, 1911.
" " "	N.E. 33-10-22-3	July 4, 1911.
" " "	S.E. 33-10-22-3	July 6, 1911.
Frenchman River	N.E. 31-6-21-3	July 31, 1908.
" "	N.E. 23-6-23-3	July 9, 1912.
" "	N.E. 16-6-24-3	July 10, 1912.
North Branch Frenchman River	N.E. 16-7-22-3	July 25, 1908.
Hay Creek	N.E. 30-10-25-3	April 22, 1909.
" "	S.W. 29-10-25-3	July 4, 1910.
Jones coulee	S.E. 20-8-20-3	May 15, 1912.
Jones coulee	S.E. 5-8-20-3	Sept. 23, 1909.
Lonepine creek	N.W. 27-7-26-3	July 17, 1909.
Moorehead ditch	N.W. 25-10-25-3	June 10, 1911.
Morrison ditch	S.W. 26-6-21-3	Aug. 22, 1911.
Needham ditch	S.W. 30-11-23-3	June 22, 1911.
Piapot creek	N.E. 18-11-24-3 †	June 17, 1908.
Pollock ditch	N.W. 22-7-21-3	Aug. 10, 1911.
Rose creek	N.E. 26-7-22-3	May 2, 1911.
Skull creek	N.W. 10-11-22-3	June 29, 1908.
" "	N.E. 29-10-22-3	Apr. 8, 1911.
Sucker creek	N.W. 24-6-26-3	May 26, 1909.
Swiftcurrent creek	S.W. 22-7-21-3	May 18, 1909.
" "	Sec. 17-10-19-3	May 27, 1910.
"	Sec. 18-10-19-3	June 15, 1910.
Strong & Day ditch	N.E. 25-6-22-3	July 31, 1908.

† This station was originally located on S.W. 17-11-24-3, but was moved to its present location on May 13, 1909.

As the records had not been altogether satisfactory at the old gauging station on Belanger creek, a new gauging station was established farther downstream, but owing to some changes in the ownership of the ranch, the gauge at the new station was not read continuously. The two new gauging stations on Frenchman river above east end were finished and put in good shape in July, and the records on this stream will in future be more complete and satisfactory.

Special gaugings were made of Barnett ditch (section 17-7-22-3), Blacktail creek (N.W. 30-6-23-3), Calf creek (section 5-8-22-3), Concrete coulee (section 11-7-23-3), Cross ditch (section 5-8-22-3), Dimmock creek (section 10-11-21-3), Doyle coulee (section 17-7-22-3), Frenchman river (N.E. 21-5-17-3 and N.E. 22-6-25-3), Maple creek water main (N.W. 20-10-25-3), overflow of Maple creek water-works reservoir (N.W. 20-10-25-3), Saunders' springs (section 20-10-25-3), and a spring creek on S.W. 7-6-16-3, whenever possible.

Beaver dams have become so numerous on some of the streams in this district that it is difficult to get satisfactory records of the flow.

Provision should be made so that two hydrographers can be placed in this district also during the spring, and so that they can start field work on or shortly after the middle of March.

Winter records would be of little value in this district and none have, therefore, been taken.

G. H. Whyte was in charge of the field work in this district until May 10, when he was transferred to the Battleford district. J. S. Wright, Grad. R.M.C., was then placed in charge of this district, and finished up the field work and made the final computations for the annual report. Reports of the field work done by Messrs. Whyte and Wright are attached.

MOOSEJAW DISTRICT.

This district includes the following regular gauging stations:—

Stream.	Location.	Date Established.
Boxelder creek	N.E. 2-12-30-3	May 24, 1909.
Bridge creek	S.E. 23-13-19-3	Mar. 29, 1911.
Bullshead creek	Sec. 16-12-5-4	July 26, 1909.
Long creek	S.E. 10-2-8-2	June 22, 1911.
Mackay creek	N.W. 26-11-1-4	July 29, 1909.
Moosejaw creek	N.W. 16-16-26-2	Apr. 7, 1910.
" "	N.W. 14-15-25-2	Apr, 13, 1910.
" "	N.W. 19-11-18-2	June 21, 1911.
Qu'Appelle river	S.W. 33-19-21-2	May 12, 1911.
Ross creek	N.W. 31-11-2-4	July 28, 1909.
Sevenpersons river	N.E. 30-12-5-4	Apr. 27, 1910.
Souris river	N.E. 11-2-8-2	June 23, 1911.
" "	N.E. 36-2-1-2	June 26, 1911.
" "	Sec. 6-4-26-1	July 20, 1911.
South Saskatchewan river	N.W. 31-12-5-4	May 31, 1911.
Swiftcurrent creek	S.W. 30-15-13-3	Apr. 30, 1910.

The number of regular gauging stations in this district is comparatively small, but owing to the long distance between gauging stations and the importance of some of these it is impossible to increase the number of regular gauging stations in this district. It has, however, been found that records of Moosejaw creek on the northwest ¼ section 14, township 15, range 25, west of the 2nd meridian, are of little value and this station will be abandoned. If a suitable site can be found near the eastern boundary of Saskatchewan another gauging station will be established on Qu'Appelle river.

Special gaugings were made of Thunder creek at Moosejaw whenever possible.

There are now eight dams on Moosejaw creek in connection with domestic and industrial water supplies, and at least one other is contemplated. There are also about the same number of dams on Souris river. Though small and of an inferior quality, the water supply from these streams is very valuable. In order to intelligently administer the regulations and deal with new applications it is absolutely necessary to obtain continuous records of the flow of these streams at different points, and they are, therefore, being given special attention.

Winter records were obtained on Moosejaw creek near Moosejaw, Qu'Appelle river at Lumsden, Souris river at Estevan, Swiftcurrent creek at Swift Current, and South Saskatchewan river at Medicine Hat. The eastern portion of the Battleford district was included in the Moosejaw district during the winter months, and South Saskat-

chewan river at Medicine Hat was included in the Macleod district during the winter months.

D. D. McLeod, B.Sc., was in charge of the field work in this district until May 31, when he resigned from the staff. On June 12, H. D. St. A. Smith, Grad. R.M.C., was placed in charge of the field work. In January Mr. Smith was relieved by O. H. Hoover, B.Sc., who has carried on the field work to this date. The final computations of the records for the report have been made by Mr. Smith. Reports of the field work done by Messrs. Smith and Hoover are attached.

BATTLEFORD DISTRICT.

This district includes the following regular gauging stations:—

Stream.	Location.	Date Established.
Athabasca river	N.W. 15-45-1-6	Mar. 4, 1913
"	N.E. 5-51-25-5	Mar. 11, 1913
"	S.E. 20-66-22-4	Feb. 27, 1913
Battle river	S.E. 19-43-16-3	June 17, 1911
Red Deer river	S.E. 20-38-27-4	Dec. 2, 1911
North Saskatchewan river	N.W. 33-52-24-4	May 14, 1911
" " "	N.E. 29-43-16-3	May 18, 1911
" " "	River Lot No. 76, Prince Albert.	Oct. 2, 1911
South " "	S.W. 28-36-5-3	May 27, 1911

While there was no immediate use for records on the streams in this district when it was first started, the records are now of very great value to the Department of Public Works of Canada in their study of the North Saskatchewan river for navigation purposes; also to the Water Power Branch of this department and others interested in power development. There will be a good market for power in central Alberta, and many parties have been investigating the favourable water power sites and are awaiting records of the flow of the streams west and north of Edmonton.

H. J. Duffield, B.E., was in charge of the field work in this district until April 30, when he was transferred to irrigation work. G. H. Whyte was then in charge until the end of December, when he returned to the office. F. R. Burfield was in charge of the field work in January, and since that, V. Meek has been in charge. G. H. Whyte and R. H. Goodchild have made the final computations of the records for the annual report. A report of the field work done by G. H. Whyte is attached.

During the autumn Mr. Whyte did some reconnaissance work west of Edmonton, but as he could not leave the regular district except for short periods, he could not go far from the railway. During the winter Mr. Meek also did some reconnaissance north and west of Edmonton, and made a number of special gaugings.

During the winter almost continuous records were taken at all the regular gauging stations in this district. Those at Battleford, Prince Albert and Saskatoon were included in the Moosejaw district during the winter and the remainder in a new district, called the Edmonton district. The Edmonton district included Red Deer river at Red Deer, North Saskatchewan river at Edmonton, and Athabasca river and its tributaries. As this new district was not formed until after freeze-up and observers are very scarce, only the three regular gauging stations on Athabasca river were established, but special gaugings were made at other points on Athabasca river and its tributaries.

During the year special gaugings were made of A-la-pache river (township 57-5-6), Baptiste river (township 56-3-6), South branch of Baptiste river (township 54-2-6), West branch of Baptiste river (township 56-3-6), Beaverdam river (township

48-21-5), Dummy creek (section 33-48-21-5), Embarras river (section 33-48-21-5), Hay river (township 53-27-5), Lobstick river (S.W. 29-53-7-5), McLeod river (township 48-21-5, N.W. 5-52-18-2 and section 33-52-17-5), West branch of McLeod river (township 49-23-5), Miette river (township 47-1-6), Pembina river (S.W. 20-53-7-5), Pintohorse creek (township 54-27-3), Prairie creek (N.W. 5-51-25-5), Rocky river (near Jasper House) and Stony river (near Jasper House).

While in charge of the field work, Mr. Whyte collected considerable data concerning the largest floods on the North Saskatchewan river at Edmonton and Prince Albert and made estimates of the maximum discharges. The results of his investigations are given in a separate report.

RATING CURRENT METERS.

The rating station was kept in operation from early in May until the end of October. During this period all the meters used in the field during 1912 were rated at least once and most of them were rated twice. The meters rated for this office were as follows:—

12—W. & L. E. Gurley	Current	Meters	Pattern	No.	600
2	"	"	"	No.	617
9	"	"	"	No.	618
15	"	"	"	No.	623

In addition to these the following were rated:—

4—W. &. L. E. Gurley Current Meters Pattern No. 623, for the British Columbia Railway Belt Hydrographic Survey.

3—W. &. L. E. Gurley Current Meters Pattern No. 623, for the Manitoba Hydrographic Survey.

1—W. &. L. E. Gurley Current Meter Pattern No. 600, for the Department of Public Works of Canada.

1—W. &. L. E. Gurley Current Meter Pattern No. 621, for the Department of Public Works of Canada.

1—W. &. L. E. Gurley Current Meter Pattern No. 623, for the United States Geological Survey.

1—W. &. L. E. Gurley Current Meter Pattern No. 618, for the United States Department of Agriculture.

1—W. &. L. E. Gurley Current Meter Pattern No. 600, for the Canadian Pacific Railway Company.

2—W. &. L. E. Gurley Current Meters Pattern No. 617, for the Canadian Pacific Railway Company.

1—Haskell Current Meter, for C. Cummings, Civil Engineer of Crowsnest, B.C.

In all fifty-three current meters were rated, thirty-eight for this office and fifteen for other parties. The United States Geological Survey meter was rated in order to make a comparison of our rating with the rating of the same meter by the United States Bureau of Standards. The United States Department of Agriculture meter was rated in order to make a comparison of our rating with the rating of the same meter by E. J. Hoff, at a circular rating station at Berkeley, California, U.S.A. It is very pleasing to know that the ratings were practically the same, and that this rating station is considered one of the best in existence.

All the meters were rated by H. O. Brown, B.Sc., and an interesting article on current meter rating, written by Mr. Brown at the close of the season, is attached.

As explained by Mr. Brown, the recording apparatus, while very good, is not as nearly perfect as that used by the United States Bureau of Standards, and arrangements have therefore been made to have this office rating station equipped with similar apparatus at an early date.

BENCH MARKS.

When the stream measurement work was first started, the gauges were usually referred to a bench mark on a wooden stake or stump of a tree. These were easily shifted or destroyed and were not satisfactory. In 1911, an iron bench mark of the type used by the United States Geological Survey was adopted by this office, and was established at sixty-two regular gauging stations. During the past year, about forty-five more were established, and now almost all the gauges are either referred to a bench mark on a concrete pier or other permanent structure, or to one of these iron bench marks. Whenever an opportunity is afforded these are tied to the Canadian Pacific railway or Dominion Government levels, to determine their elevation above sea level, and are therefore also a handy reference for local levelling operations.

OFFICE WORK.

As above intimated the reports of the gauge height observers and the hydrographers are transmitted to this office by postal cards. These are copied on office forms and filed in a cabinet which is carefully indexed and where they can be referred to at any time without trouble. As the engineers completed their computations, the results were entered on convenient forms and filed in the same cabinet.

A cabinet made up of four styles of drawers is used for filing the records. The top section is used for filing the gauge height books of the observers and the current meter note books of the hydrographers. The gauge height books are filed alphabetically according to the names of the gauging stations, while the current meter note books are filed alphabetically according to the names of the hydrographers. The next section contains the postal cards sent in by the observers and the hydrographers. Both of these are filed alphabetically according to the names of the gauging stations. The third section is made up of map drawers and contains the gauge height-area, gauge height-mean velocity and gauge height-discharge curves, and plotted cross-sections which are filed alphabetically according to the names of the gauging stations. The same section contains the maps showing the outline of the drainage basins, filed numerically according to the number of the sectional sheet. The rating curves for the current meters are also filed in this section, numerically according to the office numbers of the meters. The bottom section of the cabinet consists of letter sized pockets, alphabetically arranged for each gauging station. The tables of gauge heights, discharge measurements daily gauge height and discharge, monthly discharge, and a description of the station and memoranda of any changes are filed in these pockets. The different rating tables for each meter are also filed numerically in this section and another drawer contains the monthly reports of the meteorological service.

The copying and filing of the reports of the gauge height observers and the hydrographers is entrusted to the office recorder. While doing this he must carefully examine all records to see that there are no errors or mistakes and where there are doubtful or impossible records it is his duty to have the data corrected or to ascertain the cause of the unusual condition. He also makes out the pay list for the observers and conducts the correspondence relating to the records.

All computations are checked before being used or published. For this reason, as far as possible, men with some technical education, or students in science, are engaged as helpers. The gaugings are computed by the helper and his work is checked by the hydrographer. In some instances where there is a great deal of driving and camping out, the hydrographer cannot secure a helper who can compute discharges and, in that case, he computes the discharges himself and his computations are checked in the office.

Gaugings of the flow under ice are usually made by using the multiple point method and vertical velocity curves have to be plotted to determine the mean velocity

in the vertical. The computation by this method is long and tedious and cannot be done by the hydrographer in the field. There are therefore a great many computations to be made in the office and the services of a computer are required.

During the past year G. H. Nettleton filled the position of office recorder and J. B. Gray that of office computer.

There has been a slight tendency in the past to make a big showing in the field work and to overlook the importance of the office work. Sufficient staff should be provided to thoroughly check all the reports and field books as they are received and plot the results on the gauge height-area, gauge height-velocity, and gauge height-discharge curves at once. Discrepancies in the records will then be discovered at an early date and the office will be able to keep a better check on the results and to direct the work much more intelligently. Usually the district hydrographers are young and somewhat inexperienced engineers and do not always realize the importance of some of the minor details of the work. The greater part of the chief hydrographer's time is now spent on irrigation work and he can only exercise a very general supervision over the work. It has therefore become necessary to strengthen the office staff, by the appointment of two assistants to the chief hydrographer, who will in addition to performing the duties of office engineers, act also as field inspectors. These men it is expected will make a special study of hydrology and stream measurements and by constantly checking up the field and office work bring it up to a much higher degree of accuracy.

G. H. Whyte has acted as first assistant to the chief hydrographer since the first of January last. During this time he has been in charge of the office work and assisted in compiling the annual report. G. R. Elliott is to be the second assistant during the coming year.

CONVENTIONS AND CONFERENCES.

In August last the chief hydrographer attended a Convention of the Western Canada Irrigation Association at Kelowna, B.C., as a delegate for the Canadian Society of Civil Engineers, and the Calgary Board of Trade.

The papers read at this convention were very interesting and instructive. Several resolutions of interest to this office, but more particularly relating to conditions in British Columbia, were passed. At the close of the convention the delegates were shown over some irrigated orchards and gardens in the vicinity of Kelowna and Penticton.

In January last, the chief hydrographer attended a conference of District Engineers of the Water Resources Branch of the United States Geological Survey as representative of this office. It was held at the head office of the survey in Washington, D.C., and was attended by M. O. Leighton, Chief Hydrographer of the United States Geological Survey; J. C. Hoyt, Engineer in charge of Surface Water Investigations; all the district engineers of the Water Resources' Branch, a number of assistant engineers, a representative of the United States Bureau of Standards, and five representatives from Canada. The Canadian representatives were A. V. White and L. G. Denis, of the Conservation Commission, H. G. Acres of the Ontario Hydro-Electric Power Commission, D. L. McLean of the Water Power Branch of the Department of the Interior, and the undersigned.

The papers and discussions covered the subject of stream measurement very fully, and were very instructive. One could not help but note the interest every delegate took in the subjects taken up.

While papers were not assigned to the Canadian representatives they took part in the discussions and were given the same consideration as the district engineers of the Water Resources' Branch, and the conference was always glad to hear how the work was being done in Canada.

The writer considers himself very fortunate in having had the opportunity to attend this conference, and would recommend that should invitations be received to attend any more such conferences, representatives should be sent.

A report of the conference was submitted some time ago, but as it deals more particularly with details of engineering and administrative work, it is not attached for publication.

On 26th instant, advantage was taken of the fact that all the engineers of this office employed on stream measurement work were in headquarters, to hold a conference. Considering the short notice given and that Easter holidays came in between, the papers were very satisfactory. Many important points were brought out in the papers and discussions. It also gave the Commissioner of Irrigation an opportunity to explain to and instruct the hydrographers in many matters which might otherwise have been overlooked or only communicated to a few.

It is hoped that another conference will be held next winter and that other branches of the government and other organizations doing stream measurement work will be invited to send representatives.

FUTURE WORK.

The stream measurement work will be continued during the coming year in all the old districts and every effort will be made to extend the territory covered, but the scope of the work is of course limited by the appropriation and staff available.

There are a number of important streams which rise in the mountains west of the Calgary and Edmonton branch of the Canadian Pacific railway. With the advent of railways, industries will soon be started in this district, and the water supply will be an important factor. During the coming year it is proposed to have a hydrographer make a thorough reconnaissance of this district and make a study of the water supply and particularly to get records of the flow of the North Saskatchewan river and its tributaries, as no doubt there are possibilities of water-power development in this district, and records of stream flow will be wanted.

During the past year some information has been secured regarding the flow of Athabasca, McLeod and Pembina rivers. It will be impossible to secure observers wherever desired, but it is hoped during the coming year to make a careful reconnaissance of Athabasca river and its tributaries and to establish regular gauging stations wherever the value of the records will warrant the expense of obtaining them. Our investigations in this district during the past year show, as elsewhere, that the minimum flow which occurs during the winter is much below the general expectation, and as there are a large number of possible power sites on this stream, winter records are of much value, and special efforts will be made to get records at the more important points during next winter.

Fortunately excessive floods do not occur very frequently on the streams in Alberta and Saskatchewan, but nevertheless it is most important that these should not be under-estimated when designing dams, headgates, bridges, and other works on the streams. Not only does their destruction cause heavy losses to the owners of the structures, but the lives and property of many other people are endangered. As above intimated special studies of the maximum floods on Bow and North Saskatchewan rivers at certain points were made during the past year. In future this subject will be given special attention, all available data will be collected, and the estimates tabulated in convenient form for use in designing structures at different points on each large stream.

I do not think it necessary to elaborate on the importance of continuing observations during the winter on the more important streams where power possibilities exist, but it might not be amiss to refer to the importance of studying the winter flow of some of the smaller streams in the more thickly populated districts. Domestic and

industrial water supplies have been installed to take their supply from streams which, judging from their open water flow, would provide an ample supply at all times. In several instances water-works have been installed without sufficient knowledge of the winter flow, with the result that the supply turned out to be inadequate during the winter. When the supply is from open streams this can very often be overcome by creating storage reservoirs at a nominal outlay, but in cases where the supply is from springs there is seldom any remedy. As many of the towns on the prairie are dependent for their water supply on streams with very small flow during the winter months, it is most important that they should know before designing their works exactly what that flow is, so that the scheme will include the necessary storage facilities. The railways are becoming perplexed as to how to get enough water to operate their trains during the winter months in some localities and during the past winter had in some instances to haul water for very long distances, owing to the failure of their water supply at certain tanks. Records of the discharge of all the streams in these localities, even though very small, are very valuable during both summer and winter.

Many engineers make their estimates of stream flow from precipitation records. It should, however, be pointed out that precipitation records gathered at a few isolated points are of little value in estimating the probable discharge of the streams in Alberta and Saskatchewan and often are very misleading. The physical features and the precipitation are so varied within the same drainage basin that no reliable estimates can be made. Streams such as Bow river, for instance, very often have a comparatively large run-off during a comparatively hot, dry summer, due to the fact that a much larger quantity of snow and ice is melted in the mountains in a hot, dry summer than in a cold, wet summer. In the cold, wet summer the precipitation in the mountains often falls as snow and is stored instead of coming down to still further swell the already high streams. This same condition is found on the North Saskatchewan and all other large streams whose main sources are in the mountains. It is, for instance, impossible to estimate the probable discharge of the North Saskatchewan river at Prince Albert from precipitation records and the only reliable datum to use is the record of stream flow.

To arrive at anything approaching a reliable estimate of the flow of a stream at different stages and the duration of those stages, a series of continuous records of discharge extending over a considerable period is absolutely necessary. George W. Rafter, in Water Supply Paper No. 80, published by the United States Geographical Survey says:—

'Further, it can be stated that, for records from twenty years to thirty-five years in length, the error may be expected to vary from 3·25 per cent down to 2 per cent, and that, for the shorter periods of five, ten and fifteen years, the probable extreme deviation from the mean would be 15 per cent, 8·25 per cent, and 4·75 per cent respectively.'

Mr. Rafter says, further, that with less complete records:—

'Mr Henry reached the conclusion that at least 35 to 40 years observations are required to obtain a result that will not depart more than ± 5 per cent from the true normal. The average variation of a 35-year period was found to be ± 5 per cent and for a 40-year period ± 3 per cent.'

The records of this office do not extend over a period of more than five years on any streams and during that period interruptions have occurred due to lack of funds and staff. Proper provision should be made so that this work will not in future be subjected to these interruptions.

The water supply is one of the most important resources of a country, and an accurate knowledge of the flow of water in nearly all important streams is essential for the solution of many problems in connection with navigation, water-power irrigation, domestic and industrial water supplies, sewage disposal, mining, bridge building,

river-channel protection, flood prevention, and storage for conservation of flood waters. The records of this office are being used quite extensively now by engineers and the field of operations should be extended to include other parts if not the whole of the Dominion.

I have the honour to be, Sir,
Your obedient servant,

P. M. SAUDER,
Chief Hydrographer.

REPORT OF F. R. BURFIELD, DISTRICT HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 22, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Immigration,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg to submit the following report on the stream measurement work carried out by me during the calendar year 1912.

On May 6, I started gauging work in the Calgary district. This district falls naturally into two portions (1) Bow river and its tributaries between Calgary and Bassano, (2) Red Deer river and its tributaries between ranges 15 and 7, west of the fourth meridian.

The former division embraces one of the oldest settled districts in Alberta. It lies along the main line and the Calgary-Macleod branch of the Canadian Pacific Railway, and includes the towns of Calgary, Strathmore, Gleichen, Bassano, Okotoks, and High River. This district has a considerable rainfall throughout the summer months, while the melting of the snow in the mountains augments the flow of the streams, which, in consequence, usually reach their highest stages during the months of June and July. There were no floods in this district during 1912, except one at High River in June, an account of which will be found in the description of Bow River drainage basin in Stream Measurements Report for 1912.

The part of the district north of Red Deer river has just been opened to homesteaders. The soil is fertile, though rather light, but the rainfall appears to be small and uncertain and the difficulties of obtaining water for either domestic purposes or irrigation are great. Berry creek (*i.e.*, West Berry creek), Blood Indian creek, and Bullpound creek, are the only streams with a permanent flow. The Provincial Government has sunk deep boreholes at various points, as the majority or borings under 500 feet yield alkali-tainted water.

Practically the whole of the stream measurements were made with a large Price current meter (Gurley's pattern 600); the exceptions were Blood Indian creek, Findlay and McDougal's ditch, and, in their low stages, Berry, Stimson, and Nose creeks, where I used the small meter (pattern 618). A 15--inch weir was used for gauging a spring creek at McMillan's ranch in section 10, township 17, range 1 west of the fifth meridian. I believe that a medium-sized meter could be used with advantage on the majority of streams in this district. Slope measurements were made on streams where the cross sections near the gauge appeared likely to yield reliable results, and the velocities thus obtained were used in computing the discharges in high stages.

I established one new gauging station in 1912, on Highwood river, above its confluence with Pekisko creek; it is situated at Brown's ranch, in the S.E. ¼ of section 20, township 18, range 2, west of the 5th meridian. As I was unable to obtain an observer at the station on Stimson creek, I moved the gauge about one and a half miles up stream to the N.W. ¼ of section 2, township 17, range 2, west of the 5th meridian. After the floods at High River in June considerable alterations were made in Little Bow ditch; I re-established the gauge rod in approximately its old position for the remainder of the year, but recommend that it be moved about 300 feet downstream to eliminate all danger of the gauge heights being affected by the closing of the sluice gates. A chain gauge should be placed on the right span of the traffic bridge over Highwood river at Aldersyde, instead of the present staff gauge on the left side of the centre pier. Both these changes should be made at the commencement of the open-water season.

The station on Blood Indian creek is situated below the dam used by Mr. Hallam for storing water; in consequence it affords no indication of the natural rate of flow of the stream, whilst the large flow when the gates are opened alters the cross section. It is situated about two miles from Mr. Hallam's house, and, to move it above the influence of the dam would double this distance. No other observer appears to be obtainable. As this creek is practically all used for irrigation, I presume that records are of importance, otherwise, having regard to their cost and unreliability, I should advise that the station be discontinued.

With regard to establishing a station on Red Deer river in this district, the most suitable place appears to be at the ferry at Hutton in the N.W. ¼ section 6, township 24, range 14, west of the 5th meridian, but here, as elsewhere, the bed is of shifting sand with nothing to which a gauge could be fixed. The Canadian Northern railway are proposing to cross this river near the mouth of Berry creek, and a station might be established at their bridge, when it is built, though the cross-sections at this point are not very suitable for gaugings.

I append the following statistics of the season's work:—

Number of discharge measurements made	205
Number of gauging stations maintained	18
Number of new stations established	1
Number of permanent bench marks established	4
Distance travelled by train	1,905 miles.
Distance travelled by driving	2,310 "

I also enclose a list of gauging stations in the Calgary district, and one of streams upon which miscellaneous measurements were made.*

I have the honour to be, Sir,
Your obedient servant,

F. R. BURFIELD,
District Hydrographer.

* See Report of Chief Hydrographer.

REPORT OF H. C. RITCHIE, DISTRICT HYDROGRAPHER.

Banff, Alberta, March 29, 1913.

F. H. Peters, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

Sir,—I have the honour to submit the following report of the hydrographic work done by me during the past year.

The territory covered by me during the past year extends from Calgary to Laggan, comprising all important streams along the main line of the Canadian Pacific railway, or otherwise the Bow river and its tributaries west of Calgary. In carrying on this work no camp was used and in most cases good stopping places were obtained. The streams were reached by train, walking, and the use of livery. The total distance travelled was 9,004 miles; 6,983 by train, 682 by walking, 1,339 by driving.

The method used for determining the mean velocity was the three point method; the meter being held at depths of two, six, and eight-tenths below the surface of the water. The notes were worked out in the field and the records sent to Calgary. The equipment used in gauging the streams consisted of a large and a small Price electric meter, with necessary attachments for each, manufactured by W. & L. E. Gurley, 15-inch Gurley Wye level, levelling rod, 50-foot linen tape, 100-foot steel chain tape and rubber boots.

Twelve regular stations were maintained during the summer months, and eleven during the winter. The number of discharge measurements made at regular and miscellaneous stations was 341 in all.

On the first of June, 1912, the station on Devils creek near Bankhead was abandoned on account of a dam being built in Devils canyon on Cascade river to raise Lake Minnewanka twelve feet for storage during winter months for power purposes.

A new station was established at Banff on Forty-mile creek, located in the southwest quarter of section 2, township 26, range 12, west of the 5th meridian. In most cases the standard government bench marks are used except where rock or cement piers serve as permanent bench marks.

I would recommend that a station be established on Louise creek near its source, this being the only suitable place. It should have been put in last year but was not feasible owing to many changes being made just where a good permanent section can be obtained.

Bath creek deserves some attention and on my next trip to Laggan I intend to establish a station thereon. I made inquiry last week regarding an observer and found out the Canadian Pacific railway start a fire guardian on the first of April to look after that section of the line, and he will be able to read the gauge once a day.

There were no very large floods during the past year, but I think the total flow for the year is above the average, as the change from stage to stage was very slow.

The highest record on the Bow at Banff was on August 25, due to a heavy rain.

The snowfall during the winter of 1912-13, was much larger than in the winter of 1911-1912, the average depth during this winter being sixty inches, while during last winter it was only nineteen inches. The prediction for the coming year is high water, very little rainfall, real fine summer, and some good high water records.

I have the honour to be, Sir,
Your obedient servant,

H. C. RITCHIE,
District Hydrographer.

REPORT OF A. W. P. LOWRIE, DISTRICT HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 20, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I have the honour to submit the following report on work done by me in the Macleod district during the season of 1912.

I took charge of the district on May 6, relieving Mr. N. McL. Sutherland, who had charge during the winter season, and continued the work until I was relieved by Mr. H. O. Brown, on November 23.

The district extends along the line of the Calgary and Macleod branch of the Canadian Pacific railway from Nanton south to Macleod, and along the Crowsnest branch of the Canadian Pacific railway, from Lethbridge west to the western boundary of Alberta. It includes part of the Belly river and little Bow river drainage basins, and all of the Oldman river drainage basin.

The territory is covered by train between the central towns of Nanton, Claresholm, Macleod, Lethbridge, Pincher Creek, Cowley and Blairmore. From these towns the various stations are reached by driving. Measurements on the streams were made by means of the current meter, from bridge and cable stations on the rivers and larger creeks, and by wading in the smaller creeks. The three-point method for determining the mean velocity in the vertical was used wherever possible. The notes were worked out by my helper during the eveniings and checked by myself.

The equipment consisted of two current meters, large and small size Price, with accessories for bridge, cable and wading stations, level, and weirs for the small creeks. Owing to the difficulty of carrying a weir on a train, I had weirs made wherever necessary and left them near the creeks. During the latter part of the season I used a small Price meter, pattern No. 623, for all current meter measurements, and found it perfectly satisfactory and much more convenient than carrying two meters. The cases for level rod and tripod supplied me were very poor, and I think that heavier cases would save damage to this part of the equipment on the train where they have to be forwarded as baggage.

During the season I made 262 discharge measurements, of which 170 were at regular stations, the balance being miscellaneous measurements made on creeks, principally in the Crowsnest Pass. In doing this work I travelled 1,983 miles by trail and 3,046 miles by rail.

As this district has been established for several years it has been well covered and it was not necessary to establish any new stations, though on account of the growing importance of York and McGillivray creeks I think it would be well to establish permanent stations on these two streams.

Reconnaissance work should be done in the Southfork Pass, as the streams there will be of importance when development work starts on the coal properties there. At present there are twenty regular stations in the district.

During 1912 eight permanent iron bench marks were put in. The remainder of the bench marks are on concrete piers, with the exception of Canyon and Mill creeks and the Crowsnest river, near Frank and Coleman.

Owing the unusually light fall, gradual melting and run-off of the snow in the mountains, there were no floods in the district this year, the rivers maintaining an average flow throughout the earlier part of the season and falling to exceptionally low water during September and October. Fairly high stages were reached by the creeks in the Little Bow River drainage basin.

I have the honour to be, Sir,
Your obedient servant,

A. W. P. LOWRIE,
District Hydrographer.

REPORT OF H. O. BROWN, DISTRICT HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 19, 1913

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg to submit the following report of the stream measurements work done by me in the Macleod district during the past winter.

On November 23, I met Mr. A. W. P. Lowrie, who had been in charge of the Macleod district during the past summer, at Cowley, and took over the district for the winter months. Mr. Lowrie transferred his instruments and other necessary equipment to me, the most of which was in very good order. There were two current meters, one large Price, pattern 600, and one small Price, pattern 623, but during the winter season I used the latter entirely as I found it had several advantages over the former.

This district for the winter months included the following regular gauging stations:—South Saskatchewan river, at Medicine Hat; Oldman river, near Macleod; Belly river, at Stand Off; Highwood river, at High river; Oldman river, near Cowley; Southfork river, near Cowley; Crownest river, near Lundbreck; Crownest river, near Frank; Crownest river near Coleman; Summit creek, near Crownest; and special gaugings were made of Fortier springs, near Cowley; McGillivray creek, near Coleman; and Nez Percé creek, near Coleman.

These streams are located along the Crownest branch of the Canadian Pacific Railway from Medicine Hat to Crowsnest and include the most important streams in this territory, with the exception of the Belly river at Lethbridge which was included in another district.

The equipment used consisted of: 1 Gurley Wye level, 1 levelling rod, 1 small Price current meter with weights, rods and telephone receiver, 1 stop watch, 1 50-feet linen tape, 1,100-feet steel tape, 1 pair of gum boots for wading, 1 ice axe, and 1 shovel.

The observer at each winter station was supplied with an ice chisel and ice scale.

The gauging stations upon the different streams, with the exception of the Belly river at Stand Off are located quite near to the railway, so the travelling was mostly by train and teams hired from liveries.

In the following pages will be given a brief account of the conditions at the various stations as noted throughout the winter season.

SOUTH SASKATCHEWAN RIVER AT MEDICINE HAT.

The gaugings at this station were made in each case at the regular section at the traffic bridge. Upon my first visit on December 2, the river was not frozen over and floating ice conditions made it impossible to obtain a gauging. The conditions at this station after it froze up were quite favourable for accurate measurements. The velocities throughout the section were quite uniform, though in each case rather low. It was due to this latter condition that the small Price meter proved an advantage, as the lower velocities are more accurately indicated with it. Depths of over ten feet were obtained in several places in the section. By means of a special device which I had made, I used the large sounding rods on the small meter and found it a great advantage at this station.

The location of the gauge rod used in the summer seemed hardly suitable for obtaining the winter conditions, the readings of the thickness and height of the ice at this point being affected by the over-flow from the Canadian Pacific railway pump house. During the latter part of the season observations of the ice were therefore taken by the observer near the bridge section.

OLDMAN RIVER NEAR MACLEOD.

The river at this station remained open until early in January, but the gaugings were affected by slush ice. Just before freeze-up the river was dammed below the section by slush ice and rose slightly. After freeze-up the water level again dropped, as will be noted by the records, and conditions were quite favourable for accurate gauging. The gauge rod being located in dead water might not have been quite suitable for average readings of the ice conditions.

BELLY RIVER AT STAND OFF.

At this station it was difficult to locate a suitable section for placing a gauge rod within reach of the observer. The section chosen was very suitable for the low stages of the stream, which I expected would prevail throughout the winter. However, the water flooded over the top of the ice two or three times, and at these times the gauge was not read by the observer. A chain gauge was placed near the previous summer section on the last trip to Stand Off.

OLDMAN RIVER NEAR COWLEY.

The river at this station was frozen over on my first visit on December 5. Throughout the winter the gaugings were made at the section used in the summer. The river here is quite wide and shallow and not as suitable as a narrower and deeper section, which should have been located before freeze-up.

SOUTHFORK RIVER NEAR COWLEY.

At this station open water conditions prevailed until early in the new year. The open water measurements obtained at the traffic bridge previous to freeze-up were affected by the slush ice flowing. The section at the gauge rod was not suitable for a gauging section, but a very good section was located below the traffic bridge. Water flowing over the top of the ice occurred near the end of January.

CROWNEST RIVER NEAR LUNDBRECK.

Open water conditions prevailed at this station until January. After freeze-up the water level rose considerably higher than just previous and remained quite high. This was probably due to slush ice jamming downstream. This slush ice also affected the open water measurements before freeze-up.

CROWNEST RIVER NEAR FRANK.

Open water conditions prevailed at this station throughout the winter season and the stage was almost constant.

CROWNEST RIVER NEAR COLEMAN.

At this station ice formed at the edges of the stream early in December, but open water measurements were obtained under these conditions by breaking the ice from the edges. The stream froze completely over about the first of January and measurements through the ice have been made throughout at the bridge section about 100 yards below the gauge rod.

SUMMIT CREEK NEAR CROWNEST.

At this station open water conditions prevailed all winter and a suitable gauging section for the low stages was located a short distance below the gauge rod.

In obtaining the miscellaneous gaugings upon McGillivray and Nez Percé creeks near Coleman, difficulty was experienced in obtaining a suitable section in each case. If measurements are continued upon these streams another winter, I would advise that sections be located or improved before freeze-up.

SUMMARY.

Gaugings at regular stations	58
Miscellaneous gaugings	20
Total	78
	Miles.
Distance travelled by train	3,586
Distance travelled by driving	630
Total	4,216

I have the honour to be, Sir,
Your obedient servant,

H. O. BROWN,
District Hydrographer.

REPORT OF V. MEEK, DISTRICT HYDROGRAPHER.

EDMONTON, March 26, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg to submit the following general report on stream measurements in the Cardston district from July 16 to December 31, 1912.

This district extends from the north branch of Milk river at Knight's ranch west to Waterton lakes and as far north as the Belly river at Stand Off. It includes the following lists of regular and miscellaneous stations:*

* See report of chief hydrographer.

Regular gaugings were made on all these streams up to November 23. While the roads were good a complete round of the district was made about every three weeks.

Total mileage, July 15 to November 23 1,687
Total gaugings 117

The equipment consists of two teams, democrat, light camping outfit (which was necessary at Waterton lakes), current meter and level.

The Canadian Pacific Railway Company allowed us to use a small house at their headgates at Kimball and also to pasture the horses not in use.

The method of covering the district starting from Cardston was to drive to Kimball, to the Canadian Pacific Railway Company's flumen and to Boundary creek, then to Knight's ranch on the north branch of Milk river via Taylorville, back to Kimball and to Cardston, west from Cardston to Mountain View, Belly river at West's ranch and Waterton lakes, then north to Pincher Creek and back to Cardston via Stand Off. During October shelters for automatic gauges were built on the St. Mary river at Kimball and the north branch of Milk river at Peter's ranch (see separate reports).

There was a slight increase in the flow of nearly all these streams early in July and from then until the end of the year a gradual decrease. The streams commenced to freeze about November 1, but no ice measurements were necessary until the end of December.

After November 23, no measurements were made on the small streams and the winter district consisted of the following regular stations:—

Stream.	Location.	Post Office.
Lee creek	N.W. 10-3-25-4	Cardston.
St. Mary river	N.E. 25-1-28-4	Kimball.
Belly river	N.E. 5-2-28-4	Mountain View.
Waterton river	N.E. 8-2-29-4	Waterton Mills.
St. Mary river	N.E. 26-7-22-4	Lethbridge.
Belly river	N.W. 1-9-22-4	"
Milk river	N.E. 21-16- 2-4	Milk River.
North Branch Milk river	N.E. 13-1-23-4	Taylorville.

Total gaugings on these streams from November 23 to December 31 17
Total mileage (not including train trips) 374

I would suggest that in future a winter gauging station be established on the St. Mary river at Kimball, at the ford a few hundred yards above the bridge, where the river is not apt to dam with ice. This winter the river was continually in bad condition at the bridge, making the gauge readings useless.

I have the honour to be, Sir,
Your obedient servant,

V. MEEK,
District Hydrographer.

REPORT OF J. E. DEGNAN, DISTRICT HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 22, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg to submit the following report of the hydrographic work done by me in the Milk River district during the season of 1912.

I left Calgary on April 10, arrived at Milk river on April 11, and until the 16th we were preparing for the summer's work. My territory covered from Mackie's ranch, seventeen miles west of Milk river, to Spencer's lower ranch, ninety miles east of Milk river, then thirty miles north, and west to Hooper and Huckvale's ranch on Manyberries creek.

All the stations on Milk river are equipped with cables, cable cars, guy wires and measuring wires, except the one at Milk River station, where measurements at high water periods are taken from the Canadian Pacific Railway bridge. During the season of 1912 I took 192 discharge measurements, 144 being taken at regular gauging stations, and 48 being miscellaneous measurements. I travelled in all by trail 2,950 miles, an average of 87·5 miles per week. I used one team and democrat as a conveyance, and a saddle-horse for short trips on inspections and miscellaneous measurements.

The two stations on the Deer creek were established in the spring of 1911, to determine the seepage, between R. M. and N. S. Dickenson's ranch, and the Deer Creek Cattle Company's ranch, to settle a dispute over water rights, but owing to the changing conditions of the creek, and the few gauge height observations, it is impossible to obtain accurate results. I would recommend that two or three days be spent in taking measurements at intervals of one-half to one mile apart, and at different stages of the stream. It may be possible to arrive at some conclusion in this manner. In low water stages the seepage apparently is greater, for on several occasions I found the creek dry at the lower station, and in the course of a few hours later got a discharge from 0·50 sec.-ft. to 1·00 sec.-ft. at the upper station, and at higher stages no greater difference could be found, although enough time may have elapsed to cause a difference in gauge height.

During the spring of 1912 the water rose very high in Milk river, but was caused mostly by ice-jams, and the gauge heights are of no value during this period. All staff gauges were taken out by the ice except the one at Spencer's lower ranch. On the 23rd and 24th of May the water rose again. I obtained two measurements at Pendant d'Oreille, the higher measurement being 1,188 sec.-ft., and two at Spencer's lower ranch, the higher measurement being 1,067 sec.-ft. I learned of no damage caused by the floods.

All the creeks of Pakowki Lake drainage apparently have a large discharge in the spring caused by the snow melting, and during the summer they all go dry, except during rainy periods when they have a small flow.

I concluded the field work on November 21, and returned to Calgary, to make the final computations of stream flow for the annual report.

I have the honour to be, Sir,
Your obedient servant,

J. E. DEGNAN,
District Hydrographer.

REPORT OF G. R. ELLIOTT, DISTRICT HYDROGRAPHER.

Irrigation Office,
Calgary, Alberta, March 20, 1913.

F. H. Peters, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

Sir,—I have the honour to submit the following report of my work in the field during the season of 1912.

The Western Cypress Hills district, of which I was in charge, consists of the block about sixty miles square lying between Medicine Hat and Maple creek and the International boundary. The Cypress hills, lying east and west, divide the district into two watersheds, and the Fourth meridian, between Alberta and Saskatchewan, also passes through the middle of the district.

The streams contained in this district are in general small. Very few of these have an important summer discharge. However, the numerous small creeks are nearly all utilized for irrigation during their flow in the spring months.

The number of gauging stations now maintained is 36. This includes 12 stations on irrigation ditches. The river stations consist of one cable station, five bridge stations and 18 wading stations. With the exception of one chain gauge at the bridge station on Battle creek, all gauges are plain staffs, graduated in feet and hundredths, fastened vertically to posts in the stream.

On May 6, I took over the work of the district from Mr. M. H. French. I returned to Calgary on November 30. During the season I made seven rounds of the district from the headquarters at Maple creek. The total mileage travelled was 2,746. The number of gaugings made was 214. Three new stations were established and the positions of four stations were changed. Ten slope measurements were made. Permanent iron bench marks were established at twelve stations, thus completing this work at all stations in the district.

Mr. French's helper, J. G. Beattie, continued on the work for one trip, after which he left to work for the Canadian Pacific Railway Company. Mr. T. R. Elliott was my helper from June 8 to September 27, when he returned to the University of Toronto. I secured another competent man in Medicine Hat, Mr. K. Gwynn, who remained till the end of the season. With the exception of the first trip, I used the same team which has been in use in this district for several years. For the first round, on account of the lameness of one of the horses, I exchanged with Mr. Duffield for one of his teams.

All the travelling was done with team and democrat. The load carried was made up of tent, beds, gauge rods, tools and instruments. Also oats had to be carried a

considerable part of the time. The load, therefore, was fairly heavy. The instruments carried for gauging were a Gurley electric current meter, and a 24-inch weir. A 15-inch Wye level and 12-foot folding level rod were used for cross-sectioning, establishing bench marks, making slope measurements and for measuring heads on the weir.

Meter measurements were all made by wading. No high discharges were encountered during the summer. The depth was small enough at all times to employ the six-tenths' method of metering. The weir was used for 65 gaugings, exclusive of discharges which were nil or almost nil. When the stream was gauged at a point other than the permanent section and when the weir was used, the area was obtained at the permanent cross-section for plotting the area and mean velocity curves. All discharge measurements were worked out in the field and sent in to the office on discharge cards. The meter books when completed and indexed were also mailed to the office. All computations were made by my helper and checked by me. Slope measurements of discharge were made by cross-sectioning the stream at several places and obtaining the area from the observer's high reading and measuring the slope at the existing stage. This method was the only way in many cases to obtain even an approximate value for the spring flood discharge. All slope measurement and station description forms were filled out complete and forwarded to the office.

The spring break-up took place on nearly all the streams between April 3 and 7. On all creeks the spring discharge was very high on account of the unusual depth of snow. This, however, was the only flood of the season. The summer flow was much below that of 1911. More than one-half of the 24 river stations registered no discharge at some time during the summer. Some of these streams flowed again in the fall. The majority of them for the remainder of the season showed only standing water or were completely dry.

I would recommend that a cable station be established on Lodge creek, at Willow Creek police detachment. The highest flood discharge of the district took place at this station. There should be at least one place on this creek where flood measurements can be properly taken. Battle creek, whose flood discharge was the next largest, is equipped with a bridge station. I would also recommend that, to as great an extent as is possible, extra men be placed in this district during the spring run-off, in order to obtain more satisfactory measurements of the high discharges. The highest flood discharge drops below one-fourth in three or four days, and it is therefore necessary that one man should not have a large area to cover. The mileage in this district proportional to the number of stations is somewhat great. After the middle of May the district can be sufficiently well covered by one hydrographer.

I attach a list of the gauging stations revised to date, and a list of the miscellaneous gaugings made during 1912.*

I have the honour to be, Sir,
Your obedient servant,

G. R. ELLIOTT,
District Hydrographer.

* See Report of Chief Hydrographer.

REPORT OF J. S. WRIGHT, DISTRICT HYDROGRAPHER.

Irrigation Office,
Calgary, Alberta, March 22, 1913.

F. H. Peters, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

Sir,—I have the honour to submit the following report of the work done by me in the Eastern Cypress Hills district, during the season of 1912.

On May 10, Mr. G. H. Whyte, district hydrographer, transferred all the stores and equipment to me, and I carried on the work in the district until November 28, when I returned to Calgary.

The district lies north and south of the east end of the Cypress hills and comprises practically the whole of the Frenchman river, Swiftcurrent creek, Antelope lake, Lake of the Narrows, Crane lake and Hay Lake drainage basins.

Travelling is done entirely with horses and a small camp outfit is supplied, but as a rule, food and lodging can be obtained from the ranchers and farmers in the district. During the season we covered about 2,590 miles with the one team of horses.

Wherever possible, gauging stations have been established on the bridges, but there are also two cable stations in use, and on the smaller trout streams gaugings are made by wading, and when the flow is small a weir is used.

During the season a total of 274 discharge measurements was made, 40 stations were maintained, four of which were established during 1912. Thirteen permanent bench marks were established, leaving only three stations on streams that are not now supplied with permanent iron bench marks.

During the spring, all the streams were in heavy flood and the floods did damage to the extent of about $9,000. The summer's rainstorms, though frequent, were not heavy enough to cause any bad floods, but they kept most of the creeks at a regular flow. Three creeks went dry during the summer, but for a few weeks only.

Many of the creeks in the district are affected by beaver dams which make it difficult to make accurate estimates of the discharge.

Several stations are badly located, but as the country is thinly populated the stations have to be established where it is possible to get a gauge reader. The gauge readers generally are fairly reliable, but if we find them faking their records, the station has either to be abandoned, or we have to let the same reader continue, trusting that a large percentage of his readings will be correct. This lack of good observers makes a great handicap for accurate computations in regard to run-off in acre-feet, &c.

I have almost completed working out my season's notes and find that shifting conditions occur at a great many of the stations. This might possibly be caused by poor measurements, but I find in looking over Mr. Whyte's notes of 1911 that he found similar conditions at many of the stations.

As the flow of Rose creek at East End post office and of Lonepine creek at Hewitt's ranch is fairly regular after the spring floods, and the discharge is small, I would recommend that permanent weirs be established at these stations. The weirs could

be taken out at the end of the season's work and replaced again after the spring floods.

I would also recommend that the district hydrographer be supplied with a saddle-horse to assist him in covering his district more thoroughly.

I have the honour to be, Sir,
Your obedient servant,

J. STANLEY WRIGHT,
District Hydrographer.

REPORT OF H. D. ST. A. SMITH, DISTRICT HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 20, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg leave to submit the following report on the work done by me in the Moosejaw district during 1912.

I took charge of this district, which has formerly been looked after by Mr. D. D. MacLeod, on June 12. This district extended from Medicine Hat in the west to Regina in the cast, along the main line of the Canadian Pacific Railway Company. From Regina I went north on the Canadian Pacific Railway as far as Lumsden, and from Moosejaw south along the Portal section of the Canadian Pacific railway to Estevan, thence east on the Estevan branch of the same railway to Melita, Manitoba. In this district there were sixteen regular gauging stations.

The summer work was carried on by me until November 15, when some changes were made in the district. Winter work was carried on at the following stations of the Moosejaw district: South Saskatchewan river at Medicine Hat, Swiftcurrent creek at Swift Current, Moosejaw creek near Moosejaw, Souris river at Estevan and Qu'Appelle river at Lumsden. To these five stations were added the following stations formerly in the Battleford district: South Saskatchewan river at Saskatoon, North Saskatchewan river at Prince Albert, North Saskatchewan river and Battle river at Battleford. These nine stations comprised the Saskatoon district for winter work.

I took over this part of the Battleford district from Mr. G. H. Whyte, who had been carrying on summer measurements in that district. I joined Mr. Whyte in Saskatoon on November 25, and went over the district with him. On December 22 Mr. O. H. Hoover joined me at Moosejaw, and, after going over the district with me, he took charge of the district for winter work.

During the summer, while on the Moosejaw district, I made my headquarters at Moosejaw, making trips south and west every alternate week. I found that by doing this, I could cover the entire district in two weeks. My travelling was done almost entirely by train with short drives from the various towns to the gauging stations.

My equipment consisted of two Price meters, one large and one small, with cables and equipment for use at bridge stations and rods for wading measurements, and a level for cross-section work and gauge checkings. For stations where it was necessary to use weirs, I procured wooden weirs and left them near the station, as I found that it was very difficult to carry weirs with me on account of the difficulties experi-

enced in carrying them on trains. I used only the large Price meter at one station (South Saskatchewan river at Medicine Hat) during the summer season, the small meter being better adapted to the small streams of this district.

During the summer work sixteen stations were maintained in the Moosejaw district and during winter work nine stations were maintained in the Saskatoon district. During the actual summer season (*i.e.* from June 12 to November 15) I travelled 11,513 miles by train, 732 miles by trail and made 151 gaugings. While on winter work I travelled 4,419 miles by train, 40 miles by trail, and made 22 gaugings, thus making a total of 15,932 miles by train, 772 miles by trail, and 173 gaugings. I established three permanent bench marks, took one cross-section and made two inspections of industrial water supplies.

When I took over the Moosejaw district I found that the spring floods were all over and the only stream on which I found that any damage had been done was Ross creek, at Irvine. On this creek the highway bridge on the northwest quarter of section 31, township 11, range 2, west of the 4th meridian, was partially destroyed. On the other streams, although the water was high, I did not hear of any damage being done. Several creeks in this district went dry during the summer, while others were dry for short periods. Boxelder creek ceased to flow on June 11, and started again June 16, stopped again June 22, and remained dry for the rest of the season. There was high water on this creek from March 24 to April 12. MacKay creek, at Walsh, ceased to flow June 28 to July 12, and from July 15 remained dry till the end of the season. High water at this station lasted from March 26 to April 12. Bridge creek, at Gull lake, was dry periodically from June 28 to August 15, when it ceased to flow for the remainder of the season. There was high water at this station from April 17 to 19. Moosejaw creek, at Pasqua, was dry from September 10, and was high from April 1 to April 20, and from May 6 to May 25. Moosejaw creek, at Lang, always had water at the station, although after October 5 there was no flow. High water prevailed at this station from April 1 to April 20, and from May 5 to May 24. At the remaining stations there was a flow all season, although at times this flow was very small.

I would recommend that the stations on Moosejaw creek, at Lang and Pasqua, be given up and that the district from Swift Current west be taken off this district.

Please find attached a list of stations, with their locations* and observers.

I have the honour to be, Sir,
Your obedient servant,

H. D. St. A. SMITH,
District Hydrographer.

* Not printed.

REPORT OF O. H. HOOVER, DISTRICT HYDROGRAPHER.

Prince Albert, Saskatchewan, April 7, 1913.

F. H. Peters, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

Sir,—The following is my report covering the stream measurement work in the Moosejaw hydrographic district from December 22, 1912, to March 31, 1913.

In looking over this district one sees that the railway accommodation as regards visiting the larger rivers is fair, and consequently the hydrographic work during the

winter months is confined chiefly to measurements taken at stations convenient to the railwaps. The district, is of course, of considerable size, and time spent in travelling must be minimized in order that each station may be visited at frequent intervals.

TERRITORY.

The territority covered in this district is bounded on the west by Swift Current and Battleford. Points on the eastern boundary visited are Estevan, Regina, Lumsden, Saskatoon and Prince Albert, and all the territory between these two boundaries lies well within the district.

METHOD OF CARRYING ON THE WORK.

All the work here dealt with, with exception of the station at Estevan, has been subject to ice conditions, and the discharges have, without exception, been obtained by use of the current meter.

On the smaller rivers, namely, of 100 feet or under in width, meter records were taken at intervals of from three to ten feet, according to the nature of the river bed. On the larger rivers, however, as in the case of the Saskatchewan where the channel is wide (over 600 feet) and ice conditions giving a maximum depth of 3·90 feet, holes for metering were projected at 20-foot intervals and 10-foot intervals when approaching piers or obstructions of any nature.

All meter records where the depth would permit were taken at the following points:—Initial, just below the surface of the ice or at the level, where ice friction operates, and thence, one, three, five, seven and nine-tenths of the actual water depth.

PROJECTING HOLES THROUGH THE ICE.

Where the ice is over three feet thick it is a difficult proposition to obtain efficient ice-cutters. The work, of course, only lasts for two or three days each visit, and the amateur (as most of the workman obtainable will be found to be) takes twice as long to project one of these holes as the more skilled worker. It is therefore, I may add, important that helpers be located on the first winter visit who can be obtained on each succeeding visit while the winter lasts.

EQUIPMENT USED IN THE DISTRICT.

The equipment used in this district consists of the following:—One large current meter, one small current meter, one engineer's level, one level rod, two pair rubber boots, one stop-watch, one steel tape, and one metallic tape. Also at each station it is nessary to have at least one ice chisel, one ice scale, and two or more axes, according to the size of the river.

STREAM STAGES.

Swiftcurrent creek at Swift Current.—The discharge of this creek decreased steadily as the winter advanced and on January 21, 1913, there was no flow taking place at the regular gauging station on the S.W. ¼ section 30, township 15, range 13, west 3rd meridian. On my next visit, February 15, this creek was perfectly dry, even above the Swift Current water-works intake, and in conversation with Mr. Mackie, town engineer of Swift Current, he informed me that the creek had been dry for at least two weeks previous. On February 17, 1913, the first spring flood took place in this creek, and on the following day I found the discharge above the town intake to be 5·28 sec.-ft. Although cold weather continued after this date the discharge in the creek has been continuous to the present date.

Moosejaw creek near Moosejaw.—The discharge of this creek has been exceedingly small since my coming to the district. At the time of my first gauging on January 18, 1913, no flow was obtainable at the regular gauging station in N.W. ¼ section 16, township 16, range 26, west 3rd meridian. Further, no water was passing the Canadian Pacific Railway dam located nearer the city of Moosejaw. The first spring flood waters were coming over the ice of this creek on March 28, 1913.

Souris river, at Estevan.—At the regular gauging station on this river on the N.E. ¼ section 11, township 2, range 8, west 3rd meridian, a small discharge has been recorded most of the winter; however, on my visit to this point on February 24, 1913, the creek was dry, but the Canadian Pacific Railway reservoir, located just above the gauging station, was practically full of water. On March 27 the spring freshet had just begun and the flow of this river was much increased.

Qu'Appelle river at Lumsden.—During January and February of this year the flow of this river was extremely small, and insufficient to be recorded by a current meter, but on March 15 a considerable discharge was recorded. This was flowing on top of the ice and below a thin film of newly-formed ice.

South Saskatchewan river at Saskatoon.—The measurements of this river have been subject to ice conditions during the entire winter. On each return visit as the winter advanced the ice was found to be thicker, until a maximum average thickness of about 2·70 feet was obtained.

North Saskatchewan river at Prince Albert.—All my measurements at this station have been made under ice conditions and on the following dates:—January 1, January 31, and March 1, 1913. On each return visit the discharge area was much decreased and the final average thickness of ice was about 3·00 feet. The temperature at this station was severely cold.

North Saskatchewan and Battle rivers at Battleford.—All my measurements to date at these stations have been made under ice conditions, and as regards their stages, I can only say that the cross-sectional areas continually decreased as the winter advanced. On March 10, water was flooding on the Battle river and also the north channel of the North Saskatchewan at Battleford, making it impossible to make gaugings.

GENERAL.

Number of discharge measurements made..	36
Number of gauging stations maintained..	9
Number of new gauging stations established..	0
Number of permanent bench marks established..	0
Distance travelled by train..	5,199 miles.
Distance travelled by driving..	71 "

The bridge over the Saskatchewan river, near The Pas, it is expected, will be completed in May, when the work of track-laying will be started. A large amount of steel has been ready for some time, but the work could not proceed owing to the difficulty of getting the rails across the river.

I would like to recommend that an investigation be made regarding the installing of a new gauging station on the Saskatchewan river at the point where the Canadian Northern Railway Hudson's Bay route crosses the river and near The Pas. The abutments for the bridge (railway and traffic combined) at this point are at present in place, and the construction of the bridge will be rushed to completion at an early date according to the latest official reports.

Another large stream, Carrot river, also lies in this locality and seems to have a large drainage basin in Saskatchewan. A suitable gauging station for this river might also be located near The Pas.

I have the honour to be, Sir,
Your obedient servant,

O. H. HOOVER,
District Hydrographer.

REPORT OF G. H. WHYTE, DISTRICT HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 24, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I have the honour to submit the following report of the hydrographic work carried on by me during the year ending March 31, 1913.

MAPLE CREEK DISTRICT.

After completing my office work I was instructed on April 9, 1912, to take charge of the East Cypress Hills district. I arrived at Maple creek on April 10, and after outfitting and doing all the work possible in the immediate vicinity of the town, left on a round of the district.

I found that the streams in the district had been extremely high early in April, due to the excessive snowfall during the winter. A number of the gauges had been washed out and the replacing of these took considerable time. I was unable to complete this trip, having received instructions to hand over the district to Mr. J. S. Wright and proceed to Calgary.

Floods in the Cypress hills did much damage in the spring of 1912. Many of the irrigation dams in the district were destroyed, while others were damaged, as also were several bridges.

I might recommend that the hydrographic parties go into the field in this district in March and also that an additional hydrographer be employed until the first of May. This man could cover all the district north of the hills, leaving the district hydrographer free to devote all his time to the streams south of the hills. South of the hills in the east district there are twelve regular stations, and as the spring floods only last for a short period, one man can barely cover that locality and obtain the miscellaneous measurements necessary to make a thorough investigation of the surface water supply.

Since the establishing of regular gauging stations in this district, considerable difficulty has been met with in the locating of a station where the point of control remains constant, from year to year, or even during a season. To overcome this difficulty I would suggest that on some of the streams permanent weirs be established; while on others the point of control be made stationary, by the construction of a rock or timber structure, which would retard the flow of the stream as little as possible.

BATTLEFORD DISTRICT.

On my arrival in Calgary, I was employed for a few days in the office and then took over the Battleford district. This district extended over a very large part of Alberta and Saskatchewan, and although there were only seven regular stations, a great deal of time was employed in making a trip. I also received instructions to make a reconnaissance of the district west of Edmonton and tributary to the line of the Grand Trunk Pacific Railway.

On account of the high water stage on the North and South Saskatchewan rivers extending over considerable time, it was found that it would be necessary to pay close attention to these streams. In June both streams rose to a high water stage, and this stage was also reached in July, and on the North Saskatchewan again in August. The July level was the highest reached, and I was fortunate enough to obtain measurements at practically the highest level on both the North Saskatchewan at Prince Albert and the South Saskatchewan at Saskatoon. Mr. H. O. Brown was sent from the office and he obtained high water discharges at Edmonton. These measurements have enabled us to obtain curves which cover all stages of the streams and also to form a basis for estimating extreme floods on these streams. Considerable work of that nature was carried out at the request of different parties for information as to the flood discharges on the North Saskatchewan in 1899. That year, due to the excessive rainfall in all parts of the drainage basin, the river reached a level in August which was the highest in the recollection of the oldest inhabitants. .

Measurements at practically every stage of the streams in the district were obtained by the fall, and early in December I handed over that part of the district in the province of Saskatchewan to Mr. H. D. St. A. Smith. After making one round of the district under winter conditions, I returned to the office. Directly previous to the freeze-up no measurements were obtained as it was found to be impossible to use a meter on account of running ice.

The equipment used at the regular stations consisted of a large Price meter with the necessary weights and cables for the suspension from bridges. This equipment was found satisfactory in most respects, although it was found that measurements at the six and eight-tenth points in the vertical could not be made during flood stages of the streams. Therefore, it was necessary to use the surface method, that is, taking the velocity at a point one foot below the surface and applying a coefficient to reduce to mean velocity. From a study of a great many measurements, I came to the conclusion that for depths of over ten feet (on the North or South Saskatchewan rivers), 0.92 was the coefficient most suitable. It is very hard to obtain an accurate coefficient when a stream is in flood and then again a coefficient found in low stages will not apply in high stages.

In obtaining soundings, a ten-pound lead with about twenty feet of wire and then a length of rope was found very satisfactory.

The chain gauge was found to be the most satisfactory type of gauge, although the rod would be suitable if located in a favourable place. In most cases, ice and débris will destroy a rod on a pier, and very often it is impossible for the observer to get close to the pier to read the rod. In winter work, also, the chain is by far the better type of gauge.

In regard to the regular stations and the districts they cover, there is little to recommend. However, between Red Deer and Edmonton and also north of Edmonton a few stations might be established to advantage.

North of Battleford and west of Prince Albert is another district where the water supply might be looked into during the present year..

During the past year, the city of Prince Albert started the construction of a power plant to develop 10,000 horse-power at La Colle falls on the North Saskatchewan. Before many years other extensive power developments will take place on these streams, making our records of great value.

Special attention should be paid to the development of power in this district and also to the available water supply for the towns lying between the two rivers.

Floods did little damage on the lower reaches of the rivers, but at Edmonton on the North Saskatchewan, the lumber companies lost many thousands of dollars worth of logs. No lives were lost that could be directly attributed to floods in the district.

RECONNAISSANCE WEST OF EDMONTON.

One of the most important features of the work carried on during the past year was the reconnaissance of the country west of Edmonton. On account of flood conditions prevailing on the streams of the regular district during a great part of the summer, I was unable to devote as much time as I would have liked to this work. Late in July, I took a hurried trip to the end of traffic on the Grand Trunk Pacific Railway at Fitzhugh in Jasper Park, obtaining a general idea of the streams and their relative location to railway stations and stopping places.

In September, I made another trip and obtained measurements at as many points as I could. On this trip, I measured Embarras, Beaverdam and MacLeod rivers and Dummy creek on the Alberta Coal Branch. On the main line, I measured the Miette and Athabasca rivers and Prairie creek.

During October, I was able, through the kindness of Mr. Brown, forest supervisor, to make a trip with his party to the country north of the Athabasca as far as the A-La-Pache. The A-La-Pache is a tributary of the Smokey river and in the Peace river drainage basin. Measurements were made on all streams en route and a general idea of the country obtained. This country is very hilly, for the most part covered with jackpine and spruce. There are large tracts of brulé, and almost all the level ground is muskeg. The party travelled on horseback, the camp and instruments being transported by pack horses. This method of travelling is slow and little more than fifteen miles a day can be made.

On account of the valuable coal deposits in the foothills of the Rockies, both north and south of the Grand Trunk Pacific Railway, this country is developing rapidly and much greater developments may be expected, which will make a demand for stream flow records.

Northwest of Edmonton there are extensive tracts of pulpwood, and no doubt many power projects will be opened in this district within the next few years.

From the number of enquiries that have been made for information as to the flow of the Athabasca ,it would appear that the value of these undeveloped powers is appreciated.

With the completion of the Grand Trunk Pacific and Canadian Northern Railways to the Pacific, another industry bound to be established is that of milling. Where cheap power is found at the outlet of a grain growing country, there will be located the chief mills of the country.

Deposits of marl suitable for the manufacture of cement are found in many parts of this country. These deposits and the fact that the outer range of the mountains consists of a limestone formation will make the manufacture of cement one of the industries in this territory.

The presence of iron along with these other valuable natural resources makes the establishment in this country of extensive industries and large communities a surety. This will make the development of power both necessary and profitable.

This development will make the records we obtain now of great value. I would recommend that we pay special attention to the obtaining of records of stream flow in this part of Alberta. Your attention is respectfully called to the last report of the Commission of Conservation in which the value of records in this district is mentioned.

In a previous report, I have drawn your attention to a method of obtaining measurements at some distance from the railway at a low cost. This is by co-operating with the Forestry Branch.

GENERAL SUMMARY.

That meteorological observations are of great value to the success of our work, and that we are not at the present able to obtain full data in this respect is well known. The establishment of stations on the headwaters of the Athabasca and North Saskatchewan in touch with Edmonton by telegraph would be of great value not only to us but to mill owners and others. Warnings of weather conditions liable to cause rises on the main rivers could be issued in time to enable much of the damage done to be avoided. The heavy rains in the mountains during August last caused a rise at Edmonton of twelve feet in as many hours. This rise caused heavy losses, most of which could have been avoided if warning had been given.

In a general summary of the work done, one is lead to believe that our records are becoming of immense value in the development of the country, not only for power, but also for navigation and municipal water supplies.

The rapid growth of our towns makes the water supply one of the most difficult problems to cope with. In this regard I would recommend that the hydrographers be instructed to pay particular attention to all available supplies for the principal towns in their districts. The information thus collected could be published in the annual report and when sufficient data are obtained we might publish special bulletins on this subject. These might give our observations with special reference to the municipal water supply of each town. I am of the opinion that information of this character would be especially useful not only to engineers, but to the public in general.

Tabulated, the work done during the year was as follows:—

Measurements made at regular stations	84
Measurements made at other points	28
Total	112
Miles travelled by train	12,575
Miles travelled by trail	1,108
Total	13,783
Water supplies inspected	2
Drainage schemes inspected	1
Cross-sections and levels run at	15 points

I have the honour to be, Sir,

Your obedient servant,

G. H. WHYTE,

District Hydrographer.

MAXIMUM FLOOD DISCHARGE OF BOW RIVER.

P. M. Sauder, Chief Hydrographer.

Irrigation Office,
Calgary, Alberta, December 17, 1912.

F. H. Peters, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

Sir,—In accordance with your instructions, I have made an investigation of the discharge of Bow river during extreme flood stage, and beg to report as follows:—

The most destructive flood ever witnessed in the Bow river valley since its settlement occurred about the middle of June, 1897. It was brought about by a cloud burst near Castle Mountain, near Canmore, following an abnormal rainfall in the early part of June.

It is stated that the greatest flood occurred in 1879, but no data regarding this flood are available.

Another flood occurred in 1884, but inhabitants who witnessed both floods agree that the water was a foot higher in 1897 than in 1884.

Another flood which almost equalled that of 1897 in magnitude and destructiveness occurred in the early part of July, 1902.

Though the hydrographic records of this office date back to 1894, no systematic and continuous record of the stages and discharge of Bow river was kept until 1908. These records extend, with the exception of the winter months during the first two years, to date, but the only flood of any account during this period occurred in July, 1909. The maximum discharge at the bridge on the Calgary and Edmonton branch of the Canadian Pacific Railway at Calgary, in 1909, was about 23,000 sec.-ft. on July 7th.

It is very hard to estimate the loss, but in running over the damage to gardens, fences, trees, houses, lots, streets, sidewalks, destruction of bridges, railway tracks, &c., the statement is ventured that the loss caused by the flood in 1897 totalled nearly a quarter of a million dollars, in the vicinity of Calgary alone.

The rainfall for the 14th, 15th, 16th and 17th June, 1897, totalled 2·94 or practically three inches in three days and a half. During the night of the 17th the river, which was already swollen, rose very rapidly, and before midnight overflowed its banks and flooded several houses on the flats south and west of the Langevin bridge. The city fire brigade and the Northwest Mounted Police turned out with teams and waggons, which were kept going nearly all night moving women, children and furniture from the flooded districts. In all, about sixty families were driven out of their homes.

The Eau Claire power plant was flooded and the dam, which still exists, was in grave danger. One span of the Bow-Marsh bridge, which was just above the present Louise bridge in the west end of Calgary, was carried away and floating down the river intact, struck a pier of the old Langevin bridge and broke up. Several houses and the Calgary Hydraulic Company's flume were also carried away by the flood. The middle pier of the old Langevin bridge sank, but the bridge was not carried out, though it could not be reached at all from the south side.

The Calgary and Edmonton bridge was not seriously damaged, but the water broke through the grade on the south bank and carried away a part of it.

A fine residence on the south bank of the river about two miles below the city, belonging to Colonel Walker, was dropped into the river by the banks caving in, and was carried to destruction, the water having cut into the bank for fifty feet or more.

The bridge over the river on the main line of the Canadian Pacific Railway east of Calgary was not damaged, and the water did not break through the grade. The railway, however, suffered very heavy loss at several places west of Calgary. At Shaginappi Point the track was washed out, and a long stretch of it had to be re-located. From Calgary to Canmore the track and bridges were damaged and carried out at several places. The mines at Anthracite were wholly submerged.

Fish creek was also very high, and at the mouth of this stream Bow river was reported to be twelve to fourteen feet above low water mark.

Highwood river and Sheep river were also very high and did a great deal of damage. The trails were in a fearful condition, and the whole country seemed to be covered with water.

A bountiful rainfall during the latter part of June, 1902, and an abnormal downpour during the first few days of July resulted in a second very destructive flood. During the night of July 4, the river overflowed the flats to the south and west of Langevin bridge in Calgary, and again the city fire brigade and Northwest Mounted Police came to the rescue of the unfortunate inhabitants with waggons and teams. Many barely escaped with their lives. The brigade was again cut off from the south by the flood and several buildings were damaged, and, while the water was higher at this point than in 1897, the actual damage to property was not as great. Colonel Walker's barn had to be moved to save it from being carried away. A man named Wilson, living on an island near the old industrial school below the city, had a narrow escape. He was rescued from the roof of his barn, which just showed above the water.

The Canadian Pacific Railway again suffered much loss by grades and bridges being damaged and washed out. The water again broke through the grade south of the Calgary and Edmonton bridges, but the opening under the bridge on the main line east of the city again carried the floods. The Bow marsh bridge was in grave danger, but was saved by being lashed to its supports.

The rainfall in Calgary for the month of May, 1902, was 8.90 inches, and in June, 9.82 inches, while on July 4th and 5th, 1.78 inches fell in 24 hours. The whole country was flooded and the Elbow and all tributaries of the Bow were exceedingly high.

The records of this office indicate that at the Langevin bridge the greatest height of the river in the 1902 flood was a couple of feet higher than in 1897, while the records of the C. P. R. division engineer show that at the bridge on the main line east of Calgary it was several inches lower.

I find among the records of the office an estimate of the maximum discharge at Langevin bridge during the 1897 flood of 54,000 sec.-ft. It is very difficult at this date, with the data available, to compute the discharge, but this estimate was made shortly after the flood and by experienced and intelligent engineers and can, I think, be relied upon, and should be and is, in my opinion, fairly accurate. In round figures, I would place the maximum flood discharge of Bow river at the Calgary and Edmonton bridge in 1897 at 60,000 sec.-ft. I do not think the maximum discharge in 1902 exceeded this amount or quite reached it.

History goes to show that Bow river is subject to very big floods, and in designing works such as dams and bridges, a small amount at least should be added to the greatest known discharge. I, therefore, consider that between the mouth of Kananaskis river and Ghost river, 40,000 sec.-ft. should be allowed; between the mouth of Ghost river and Jumpingpound creek, 50,000 sec.-ft.; between the mouth of Jumpingpound creek and Elbow river, 60,000 sec.-ft.; between the mouth of Elbow river and Fish

creek, 70,000 sec.-ft.; between the mouth of Fish creek and Highwood river, 75,000 sec.-ft.; and below Highwood river, 100,000 sec.-ft. This discharge averages about 19 cubic feet per second per square mile for the drainage area above Calgary, about 18 cubic feet per second per square mile for the drainage area above the mouth of Fish creek, and about 16 cubic feet per second per square mile for the drainage area at the mouth of Highwood river. A run-off of 19 cubic feet per second per square mile equals a depth of seven-tenths of an inch in 24 hours.

I have the honour to be, Sir,
Your obedient servant,

R. M. SAUDER,
Chief Hydrographer.

FLOODS IN THE NORTH SASKATCHEWAN RIVER DRAINAGE BASIN.

BY

G. H. Whyte, District Hydrographer.

IRRIGATION OFFICE,
CALGARY, ALBERTA, March 31, 1913.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg leave to submit the following report on floods in the North Saskatchewan river drainage basin.

To obtain a clear idea of conditions in this drainage basin, it is necessary to give a description of the principal characteristics of the different parts of the area. The basin naturally divides itself into five parts

The first or upper part consists of the eastern slope of the Rocky mountains. While this part of the basin is not the largest in area, the greater part of the run-off is derived from it. In glaciers and the perpetual snows of the higher peaks, innumerable small streams rise and flow eastward forming large streams which empty into the main river. These streams are also fed by the melting of heavy snows and by rains which fall in the mountains at all seasons of the year. The region, being mountainous, has a tendency under these conditions to discharge a great quantity of water into the streams in a short time. This is seen each spring as the mountains, being for the most part bare of vegetation, are exposed to the sun which melts the winter's snow in a short time. If this warm weather is accompanied by rains, floods take place. The lower parts of the mountains and the valleys have a good forest cover and they alone dampen the effects of warm weather. The streams in this part would have a slope of probably 20 to 100 feet per mile.

Below the mountain division is the foothills or second part of the basin. This is the largest in area of the five parts. Here the river heads northeasterly and is joined by a great many rivers of various sizes. The valley of the river becomes better defined and deeper. The country is hilly and rough but is not as broken as the first part. The whole region has a fairly heavy precipitation and is well covered with forest. Large tracts of muskeg are found in this region and, while to a certain

extent they have a tendency to make the run-off uniform if they become well saturated, they offer less resistance than bare hillside to rapid run-off of heavy rains. The slope of the river in this section would be probably from 5 to 20 feet per mile.

From near Edmonton to the mouth of Vermilion river, the North Saskatchewan river flows through a park-like country with large stretches of prairie. Few tributaries flow into the river and the drainage area of this, the third division, is small. The valley is well defined, with few flats along the river. The slope of this section averages 1½ feet per mile.

The fourth section, from the Vermilion river to Prince Albert, is principally prairie, with a few stretches of small timber and second growth. The valley of the river is much wider and the river itself widens out into shallow reaches full of shifting sand bars. Low-lying flats border the river for the greater part of the course. The slope of this section is half a foot per mile.

The fifth and last division is from Prince Albert to below the Grand Forks, or junction with the South Saskatchewan. This section has a slope of 1½ feet per mile, made up of a series of rapids. The valley is not as deep as in the two previous sections, and the river channel is better defined. The basin is covered with a fair tree growth with very little prairie land.

Below the fifth section, but on the main Saskatchewan river, is a section which consists of a chain of lakes and lagoons surrounded by low-lying lands and muskegs, covered with trees.

From the conditions prevailing on the headwaters in the two upper sections it is seen that the North Saskatchewan river will suffer from floods of a greater or less magnitude.

The worst flood in the past fifty years, and in fact as far back as records or memory goes, took place in August, 1899.

At that time the river reached a height equal to 35·45 feet on the gauge at Edmonton, or an elevation of 2026·538 feet, Public Works of Canada datum. This height gave a discharge of approximately 180,000 sec. feet from an estimate by Kutter's formula. At Prince Albert the gauge height reached was equal to 25·9 feet on the gauge, or an elevation of 1481·997 feet Public Works of Canada datum. This height gives a discharge of 160,000 sec. feet by Kutter's **formula.**

Legends at Prince Albert and Edmonton give records of higher floods, but both seem to have been caused by ice jams in the spring. The jam at Prince Albert is alleged to have taken place some 35 or 40 years ago, while that at Edmonton took place over 80 years ago.

In 1900 the river reached a gauge height equal to 32 feet on the gauge at Edmonton and did considerable damage. Since August, 1907, we have fairly continual records and the highest gauge height reached was 26 feet on July 10, 1912, the discharge on this date being about 75,000 sec.-feet.

During the floods of 1899 and 1900 considerable damage was done all along the river, but no actual figures are available. In 1899 the low level bridge at Edmonton was in process of construction at the time of the flood, and it was found necessary to raise the piers eight feet higher that at first proposed to allow for floods of such magnitude. The water reached to within one and a half feet of the tops of the present piers, at that time.

The cause of the flood of 1899 is rather hard to decide, but in my opinion it can be accounted for by the excessive rains rather than by the melting of snows. The meteorological records at Edmonton for August, 1899, gave 6·43 inches of rainfall or 4·63 inches above the monthly mean. The mean temperature was 55·7° or 3·3° below the monthly mean. It is very probable that these conditions prevailed to a greater degree in the two upper sections. It is usual to find that the snow has practically all melted by August and, as rises had taken place in June and July of 1899, it is probable that this condition prevailed in that year. Therefore I think that the assump-

tion that this flood was caused by rains is borne out. During the whole summer the entire basin had a very heavy rainfall, and in the two upper sections this rainfall would be stored to a certain point when it would run off very rapidly and add much of the stored water to the exceptionally heavy rains of August.

A study of our records show that the time it takes for the apex of a flood to reach Prince Albert from Edmonton depends on the discharge, and a flood the size of the one of 1899 would probably take less than three days.

During the highest water of 1912 there was a difference of only 3,000 sec.-feet in the maximum discharge, at Edmonton and Prince Albert, that is the maximum discharge at Prince Albert was four per cent less than the maximum discharge at Edmonton. For a discharge of 180,000 sec.-feet the difference would probably be greater.

I have the honour to be, Sir,
Your obedient servant,

G. H. WHYTE,
District Hydrographer.

RATING CURRENT METERS BY H. O. BROWN, B.A.Sc., DISTRICT HYDROGRAPHER.

IRRIGATION OFFICE,
CALGARY, ALBERTA, November 30, 1912.

F. H. PETERS, Esq., C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR,—I beg to submit the following report on the rating of current meters.

INTRODUCTION.

The great advances during the past half century in the application of water from the natural streams for water supply, power and irrigation purposes, have led to extensive investigations being made of the flow of water in the different streams throughout the year. Especially in United States, and of recent years in Canada, under the supervision of the governments of each country, have these investigations of stream flow being carried on. In this way complete records of the flow of the streams from day to day throughout each year are being obtained.

In Western Canada, where the work in this country was first extensively introduced, a special hpdrographic survey was organized under Mr. P. M. Sauder, C.E., in 1909. The work was carried on throughout the provinces of Alberta and Saskatchewan and each year extended so that at the present time discharge measurements and observations are being made of nearly all the streams throughout these provinces.

Since stream measurements were first introduced, various methods have been employed to obtain the discharge or flow of the streams. The first methods were very crude and large errors were possible, but from time to time new and improved methods were introduced. The method of obtaining the stream discharge now almost universally adopted is the 'velocity area' method. The area of the cross-section of the

stream is obtained by the width of the cross-section being measured and soundings taken at equal intervals in the cross--section; the cross-section thus being divided into smaller sections. The mean velocity of the stream must next be obtained.

The velocity at different points across the stream may be obtained by direct or indirect methods. By the use of floats and float rods, the velocity may be obtained directly but this method is limited in its application, as the necessary conditions of the stream are usually difficult to locate. The velocity of the stream is obtained indirectly by the use of current meters, where a known relation exists between the revolutions of the meter and the velocity of the water. The advantages of the current meter are easily recognized, for with it the velocity at any point in the cross-section may be observed and the velocity observations are more easily and accurately obtained.

Since current meters were first introduced in the latter part of the eighteenth century many improvements have taken place. The first type of meter used was that of the float wheel, but this was soon modified to be used beneath the surface. In America patents were taken out as early as 1851. With these early types of meters great difficulty was experienced with the mechanical recording apparatus, due to the excessive friction, but with the introduction in 1860 of an electrical recorder this difficulty was eliminated. Of the many American types of meters which have been constructed, each for use under some special condition, those in most common use are the Price, Haskell and Fteley. The Dominion Irrigation Surveys use the different patterns of the Price meter exclusively, while the United States Geological Surveys have adopted the small Price meter for their work, which has had many improvements in its construction introduced by their engineers from time to time.

METHOD OF RATING.

Rating a current meter is the determining of the relation existing between the velocity of the moving water and the revolutions of the meter wheel. Theoretically the ratings of all meters of the same make should be the same, but, owing to slight variations in construction, the ratings differ. The accuracy of a discharge measurement depends largely on the accuracy of the rating of the meter used. Errors of observation are as likely to be too large as too small and are therefore compensating. Errors in a rating table always have the same sign and are cumulative and should therefore be reduced to a minimum

The method for rating meters now universally employed is that of moving the meter through still water with a known velocity. This method is sub-divided according to whether the meter is suspended from a car or boat and moved in a straight line, or suspended from the end of a long arm and moved in a circular path. The former is called the *linear method,* the latter the *circular method.*

In the linear method the meter is moved through still water along a straight run. A platform is placed by, or over, the water, as the case may be, carrying a track about 200 or 300 feet long, on which the car for carrying the meter is run The track is laid near the edge of the platform and the meter is suspended in the water from an arm projecting from the side of the car. The car may either be propelled by hand or electrically. Observations of the distance, time and number of revolutions for each run are noted and from these data the revolutions per second and velocity in feet per second are afterwards computed. Many runs are made for each meter, the velocity varying from the least that will cause the meter to revolve to several feet per second. The results of these runs, when plotted, defined the meter rating curve for the meter, and from this curve the rating table is computed

The circular method of meter rating differs from the linear method principally in that the meter is moved in a circular path instead of along a straight path as mentioned before, the observations taken in each case being practically the same.

The meter is suspended from an arm projecting from, and supported by, a vertical centre shaft. The shaft may also be revolved by hand or electrically and a counter-shaft with friction pulleys is used to obtain the low velocities. The meter is usually suspended from rods, for reasons stated later, and stay lines are used to keep the meter in place. A circular rating station is dependent upon a linear station for notes by which to adjust the distance of the meter centre from station centre. It has been found by practical test for a small Price meter suspended by rods that the distance is 8·95 feet, for a 60 foot run, or about 0·60 feet less than a 60 foot periphery geometrically requires, which is due to the actuating and resisting forces on a circular track.

A limited number of comparisions have been made between the circular and linear methods of rating, and it has been found that the circular method of rating cannot be relied upon for rating with the cable, owing to the swinging out of the meter which introduces an uncertainity in the distance of the run. The ratings on the rod by the circular method agree with the ratings obtained by the other method, as by the Bureau of Standards, United States Government, at their rating station at vibration of the car in the linear method, the meter, when suspended on a rod, is retarded somewhat. Therefore the results of ratings on a cable in this method are being used in preference to those on a rod, even though the meter is used on a rod. While the matter has not been fully investigated, it is believed from the data available that in actual field practice there is no difference between the suspension on a rod and on a cable. The ratings by the circular method on a rod have been found to agree with those by the linear method on a cable, which indicates that in the linear method the rod ratings are affected

DESCRIPTION OF STATION AND APPARATUS.

The current meter rating station of the Department of the Interior, Irrigation Office, at Calgary, Alberta, was constructed early in the season of 1911. It was in operation during the latter part of the open season of the same year and the results obtained proved very satisfactory. At the opening of the season of 1912 the necessary attachments were placed on the car for rating with a cable and a few other improvements made in the apparatus. The station was in operation throughout the whole season until freeze-up and, besides rating the meters used by the Dominion Irrigation Surveys, several meters were rated for other parties. In the following pages will be given a brief description of the rating station and apparatus.

The still water is provided by a concrete tank 250 feet long by six feet wide and five and a half feet deep (inside dimensions), the depth of water in the tank being maintained at about five feet. The track laid along the side of the tank upon which the car is run is of 16 pound steel rails, laid to a gauge of 32⅜ inches on 4 inch x 6 inch ties. Great attention was paid in the laying of the track to have it laid solid and as level as possible, with close rail joints (fish plates and bolts being used at every joint) in order that the car would run very smoothly. In the design of the car, which is propelled by hand, the main features have been copied from the car used by the Bureau of Standards, United States Government at their rating station at Washington, D.C.

The axles of the car run in roller bearings, and the frame supporting the front axle with bearings is attached to the platform of the car by a hinge joint. This allows the four wheels of the car to rest upon the track, though it be slightly uneven in places, and makes the level of the platform dependent upon the rear axle. It is thought that this arrangement practically eliminates all the sharp vertical movements which might otherwise be transmitted to the current meter in its travel through the water. Two iron arms project from the car to the centre of the concrete tank and these hold the rods, or cable, from which the meter is suspended for rating. Iron

arms also project on either side and at right angles to the lower arm for attaching a wire stay line to the meter, when being rated on a cable or small rods. The wheels of the car are solid castings and all the steel in the car is of heavy section, it being easier to maintain a uniform rate of travel with a heavy car than with a light one.

The diagram on plate No. 1 represents the electrical connections used for the recording apparatus at the rating station. As stated before, observations of the distance, time and number of revolutions for each run must be taken. The run is of a fixed distance of 200 feet (25 feet being left at each end for starting and stopping car), therefore the number of revolutions and time of the run only have to be observed. The time of the run is recorded automatically by an electro-magnet operating a stop watch. A switch is placed at each end of the run and the car in passing over each closes the electric circuit in which the stop watch electro-magnet is connected. This causes the steel core to be drawn up into the solenoid by magnetic force and a lever fastened to the end of the core pushes on the stop watch stem. At the beginning of the run the watch is thus started by the car closing the first switch and stopped at the end of the run when the other switch is closed. The double-throw switch is used to throw three extra cells into the circuit by moving the blade over as shown, when the switch at the *out* end of the run is to operate, for here the resistance of the circuit is increased. This arrangement prevents the watch from being struck too hard a blow by nine cells being in the circuit instead of six as required for the switch being operated at the *in* end.

The revolutions of the meter for each run are also automatically recorded by an electric recorder arranged in circuit with the meter as shown in the diagram. The circuit for recording the revolutions of the meter is ready to be closed by the contact in the meter head, when a switch on a car is thrown in, as the starting post is reached. The meter continues to record until the end of the run is reached and then the circuit is again broken by a switch on the car being opened as the end of the post is reached.

As the meter seldom records exactly at the beginning and end of each run a small error is introduced in taking the recorded revolutions as the revolutions for the time of the run. For this reason the writer adopted the following method of obtaining the data for more accurate calculations of the revolutions per second of the meter for each run.

When the car has passed the starting post, when a run is being made, as the first contact of the meter is recorded a separate stop watch is started, independent of the watch recording the time of the run. The first time the meter wheel records may be a few feet past the starting post, but the time for this unknown part of a revolution of the meter over this distance has not been recorded either. The number of revolutions of the meter after the watch has been started is observed until the meter is almost at the end of the run when the watch is again stopped at the end of a complete revolution of the meter as recorded. Thus the time for an exact number of revolutions of the meter and this exact number of revolutions of the meter have been observed for the run, and from these data it is seen that the revolutions per second are more accurately calculated. In this way the error pointed out above was largely eliminated and better defined rating curves were obtained.

RATING METERS

The method of suspension employed in the rating of the meter depends upon the type of meter. For the reasons mentioned before, all the meters that can be suspended from a cable are rated thus, but the meters designed for use on rods only, necessarily have to be rated upon the rods. When the meter is suspended by a cable, it is fastened to the upper part of a hanger to which the cable is attached and the meter in this position is free to tilt up or down. The lead weight (for large meters,

15 pounds, and for small meters, 13 pounds) to keep the meter in position in the water, is fastened below the meter upon the hanger. The stay line is fastened to the top of the hanger and to the end of the arm on the car for this purpose and facing the direction in which the run is to be made. The suspension cable used is electric cable which is about a quarter of an inch thick. This cable avoids the necessity for using an extra cable for the electric circuit and is also used upon the meters in the field. It is passed through the loop in the lower arm projecting from the car and fastened to a swivel on the upper arm. The length of the suspension cable is just sufficient to allow the meter to hang about two feet below the surface of the water, and by means of the swivel the meter is easily faced in the proper direction. Care must be taken to see that the meter rests horizontally and parallel to the direction of the run and that the electric wires connected to the meter will not cause the meter to alter its position when in motion or interfere with the meter wheel.

When the meter is suspended from rods it is, as mentioned before, placed about two feet below the water surface. The rods are firmly held in the arms projecting from the car and very light waterproof electric cable is fastened to the meter for the electric recording circuit. A stay line is also fastened to the meter, when the rods used are light enough to bend when the high velocity runs are being made. The necessity for this will be stated later in another part of this paper.

The meters are usually rated first in the condition in which they have been sent in from the field and then, if necessary ,are thoroughly cleaned, fitted with a new bearing, properly adjusted and oiled and rated again. In all cases it is necessary to see that the commutator in the meter head is adjusted to give a good contact to properly operate the electric recorder, which will not operate with as small an electric current as the telephone recorder used in the field.

In rating the meter several runs are made, usually about twenty with velocities varying from the least that will cause the meter to revolve about ten feet per second. It is very essential that the velocity for each run be uniform throughout and that this velocity be attained some distance back from the starting point, that the meter wheel may reach the corresponding revolutions per second. After the first run has been made the velocities for the following runs are increased by a half foot per second respectively, as nearly as possible, so as to give points for the rating curve which will be uniformly distributed.

For each run, as stated before, the time is automatically recorded and, the length of the run being 200 feet, the velocity in feet per second is computed from these data. Also the time of a certain number of revolutions of the meter wheel having been observed for each run the corresponding revolutions per second is computed and these results, being plotted with revolutions per second and velocity in feet per second as co-ordinates, locate the points which define the rating surve.

The rating curves are plotted on cross-section paper, the scales used being five centimetres equal to 0·5 revolutions per second on the 'Y' axis for high and low velocities and five centimetres equal to 1·0 foot per second on the 'X' axis for high velocities, with five centimetres equal to 0·5 feet per second for the low velocity curve. When two curves are drawn separately for the high and low velocities respectively, the rating curve usually consists of two straight lines, the break occurring very close to a velocity of 2·00 feet per second. Theoretically there is no pronounced break in the rating curve at this point but, owing to the fact that the curvature is so decidedly small both above and below this point, it was decided to draw the curve as two straight lines. When plotting the curve the high velocity curve is usually drawn first and the point of revolutions per second corresponding to the velocity of 2·00 feet per second is transferred to the the low velocity scale and the low velocity curve drawn from this point downward.

On each separate rating curve sheet for each meter, besides the rating curves for that meter, is placed the standard rating curve for that type of meter. This

curve is used as a comparison for the other rating curves of the meter and these rating curves being placed together on the same sheet the general behaviour of the meter from rating to rating may be observed.

CONSTRUCTION OF THE RATING TABLES.

If the rating of a meter comes within one or two per cent of the 'standard' curve for this type of meter then the standard table is accepted for this meter. If the rating shows a greater difference than this then an individual table is constructed from the rating curve.

Two general forms of rating table are in use: one which gives the velocity to the nearest 0·01 foot per second corresponding to each 0·01 revolution per second from 0·0 to that corresponding to the highest velocity, for which the meter shall be used; and another form which gives the velocity to the nearest 0·01 foot per second corresponding to a certain number of revolutions in a certain number of seconds. The number of revolutions for this latter form of rating table is 5, 10, 20, 30, &c., and the time period being 30 to 60 seconds or 40 to 70 seconds. During the past season both these general forms were made out for each meter by the Department of the Interior, but it is intended to adopt the Revolution-Time form. The 40 to 70 second form of the Revolution-Time table has been used because of the lower velocities given and also the time of an observation being necessarily increased, but it also has the slight disadvantage that the velocities do not increase continuously between the 5, 10, and 20 revolution columns as in the 30 to 60 second table.

The Revolutions per Second—Velocity per Second table is constructed from the rating curve by reading the V. P. S. corresponding to each ·05 R.P.S. and then filling in velocities corresponding to each ·01 R. P. S. by dividing the differences evenly. The rating table of the second form gives the equivalent R. P. S. for the number of revolutions for each second of time between 40 and 70, so in constructing the table of this form observations are taken from the curve of the velocities corresponding to each five seconds of time throughout the table. The difference in this form cannot be divided evenly between these points because the R. P. S. do not increase uniformly, so the difference must be divided proportiontlly to the increase of R P.S. When the table of the first form is constructed first, the greater part of the table of the second form can be filled in from it thus reducing the number of calculations.

One disadvantage given by engineers in connection with the table of the second form is that it is necessary to interpolate to obtain the velocity, when the time of the observation is observed to the fifth of a second. For the low revolution columns it is not necessary to interpolate if the time is observed to the nearest half second, as the velocity increase is small, but in the columns from 20 revolutions upwards the velocity differences increase rapidly. The time being observed to the fifth of a second it seems, to the writer that tables made out for each fifth second would be very helpful. These could be constructed by the engineer from the present form of rating table for velocities between the limits in his work.

SOME OBSERVATIONS REGARDING METER RATING.

During the season of 1912 only a limited number of experiments in connection with current meter rating could be carried on at this station because of the large number of meters rated for field use by the department and also for outside parties. In connection with these experiments and the regular work, however, some interesting observations were made which will be noted in the following. Some of these observations are verified by the United States Geological Survey ratings, but others the writer would like to see taken up by other rating stations.

Several small Price meters (pattern 621 and 623) were rated suspended from a cable and in the same condition suspended from rods. For each meter the rating upon the rods gave a *lower curve* than that for the meter suspended from a cable. This difference is shown by the rating curves on plate No. 2. Also several large Price meters (pattern 600) were rated upon a cable and upon rods respectively. For each of these meters the rating upon the rods gave a *higher* curve than that upon the cable or just the opposite to what was observed for the small meters. Curves illustrating this are also shown on plate No. 2.

The small Price meters (pattern 618), which are for use on rods only, when rated upon rods supported with a stay line, and again unsupported, gave two different rating curves. For the low velocities the curves are almost identical but for velocities approximately above three or four feet per second, the rating curve for the meter unsupported gradually drops below that for the other rating (see plate No. 3). This is probably due to the rods bending a good deal in the higher velocities, when unsupported, and thus tilting the meter downwards which lowers the R. P. S. corresponding to the V.P.S.

Some of the large Price meters, pattern 600, when sent in from the field to be rated had the cone points worn round on top and also the tips loosened. The ratings of these meters in this condition in each case gave a low rating curve compared with the 'standard' for this pattern. The meters being fitted up with new cone bearings and rated again gave in each case a rating curve almost identical with that for the old bearing. The reason for this may be that the shaft bearing upon the meter wheel which bears upon the cone would probably have become worn to fit the old cone bearing and thus the sharp point of the new cone bearing would not remain at the centre of the worn shaft bearing.

Three or four meters of the small Price pattern were sent in by outside engineers to be rated at the station, and each of these meters had the cups on the bucket wheel badly battered. The bottoms of the cone-shaped cups, which were originally circular, were, in some cases very irregular, yet, for each meter the rating curve obtained was considerably above that of the standard curve for this type of meter. The curves on Plate No. 4 distinctly show this difference. The cause of this difference seems to be the change in shape and size of the cups due to being battered, for otherwise the meters were in good condition.

In rating the small Price meters of pattern 618, it was noted that the yoke shaped frame holding the bearings, when at right angles to the direction of the run (or nearly so), allowed the wheel to revolve more easily than when parallel to the direction of the run. Therefore it was necessary to see that this frame was parallel to the direction of the run to give a constant rating. The ratings of pattern 623 meters with penta and single revolution commutators were found to be identical.

When a strong wind was blowing directly down the tank it was found to cause currents in the water, which affected the ratings. This was noticed as the number of revolutions of the meter passing over the same distance at the same velocity (approximately) was not the same when going against the wind as when going with the wind, there being less when going against the wind. This may hardly seem what would be expected but the meter being placed about two feet below the surface is probably affected by undercurrents, compensating for the surface currents, caused by the wind, and in the opposite direction to these surface currents.

It has also been observed that it is most essential for the car to be started at a distance back from the starting post at the speed to be maintained throughout the run so that the meter may be revolving uniformly upon the start. Though the proper speed of the car may be attained by starting only a short distance from the post, the bucket wheel of the meter cannot attain the corresponding speed as quickly and will therefore continue to accelerate after the run has started.

REQUIREMENTS OF MORE EFFICIENT EQUIPMENT AT RATING STATION.

The three essential functions for ideal rating may be summed up as: (1) uniform speed over a run of known distance (2) exact number of revolutions of meter wheel for this run and (3) exact time of run. Practically the rating equipment is constructed to fulfil these requirements as nearly as possible and should come very close to giving the best results.

When the car is propelled by hand a great deal of care must be exercised in order to keep the speed uniform throughout the whole run. Even after a good deal of practice, slight variations in the speed, throughout the run, are often noticeable. For this reason an electrically driven car with a motor having a wide range speed control and supplied from a constant voltage line is to be preferred to the hand driven car. The cost of the installation of the necessary equipment to have the rating car electrically driven might seem to be high at first cost, but this would be compensated by the fact that the services of an operator for propelling the car would not then be required.

The equipment and methods employed in obtaining the observations do not fulfil the necessary requirements as closely as that of the equipment adopted recently by the United States Bureau of Standards, though with care very satisfactory results have been obtained.

This new equipment referred to, and also its operation, may be briefly described as follows: A cog wheel is electrically operated at each contact of the meter wheel, being moved by one cog for each complete revolution of the meter. Two pins are spaced in this cog wheel, the distance apart representing the number of complete revolutions of the meter desired for the run. These pins make the electrical connections which cause the apparatus recording the time, &c., to begin to operate at the beginning of the run and show the recorded results at the close of the run. The starting pin is placed a sufficient distance ahead of the contact point so that the desired speed may be obtained before the run over which the readings are to be taken, is commenced. When the starting pin closes the contact the time recorder is automatically started and also an arrow is shot into a soft pine plank to mark the start of the run. When the meter in passing over the run has recorded the number of revolutions for which the end pin has been placed, this end pin now causes all the recording apparatus to be stopped and also another arrow to be shot into an end plank marking the end of the run. The distance between these arrows, giving the distance of the run, is determined and the other data for this run are read from the recorders.

The disadvantage of having the run of fixed length is, as pointed out before, that it is impossible to obtain the exact number of revolutions of the meter, but this disadvantage was partly overcome as mentioned. The new method of obtaining the time and distance of the run for an exact number of revolutions of the meter will be seen to be the more accurate method and would reduce the time required for the rating of a meter, as shorter runs than at present could be used. I would recommend that the Department install this new equipment at the beginning of next season.

I have the honour to be, Sir,
Your obedient servant,

H. O. BROWN,
Hydrographer.

A. Ice conditions on the Hananaskis River near Hananaskis—ganging car for summer use in right hand corner of picture.
B. Bridge over Saskatchewan River at Battleford gangerod to left of picture.

Looking up Qu'Appelle River from Station.

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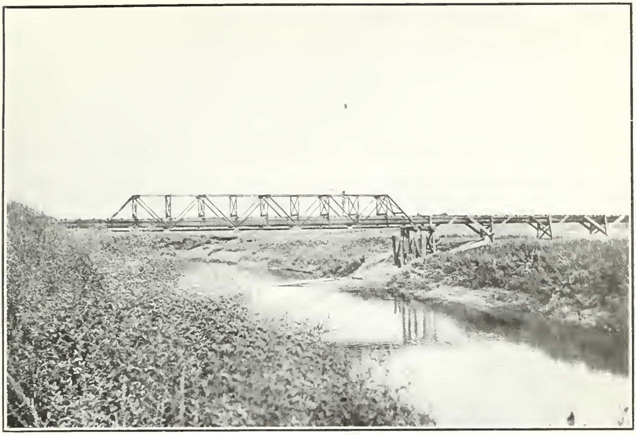
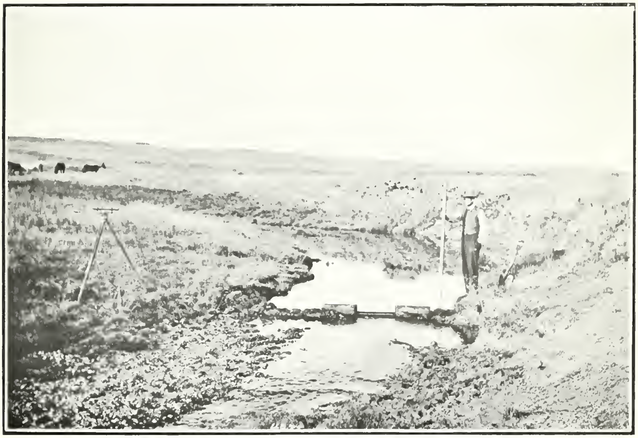
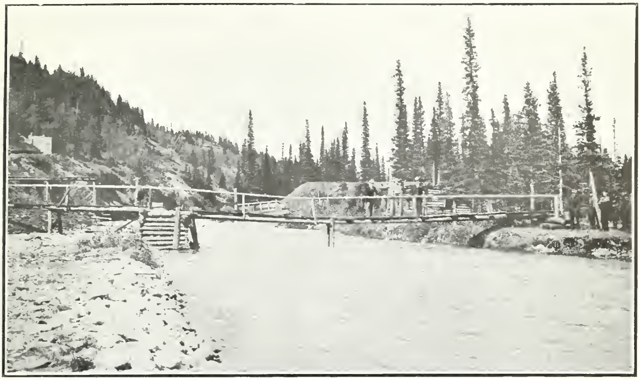


Steel Flume on Frenchman river, Maple Creek district.

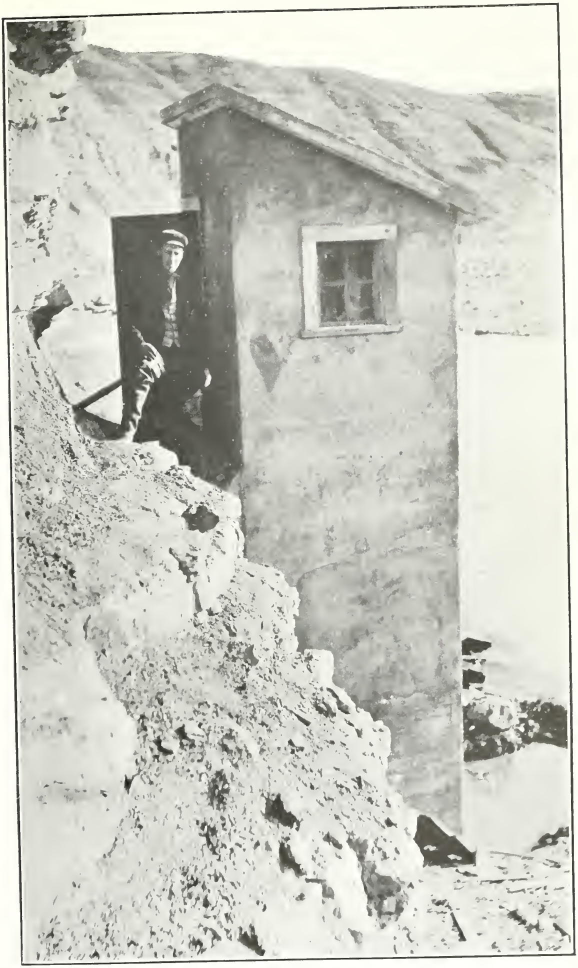


Weir Gauging of Middle Creek at Angus McKinnon's



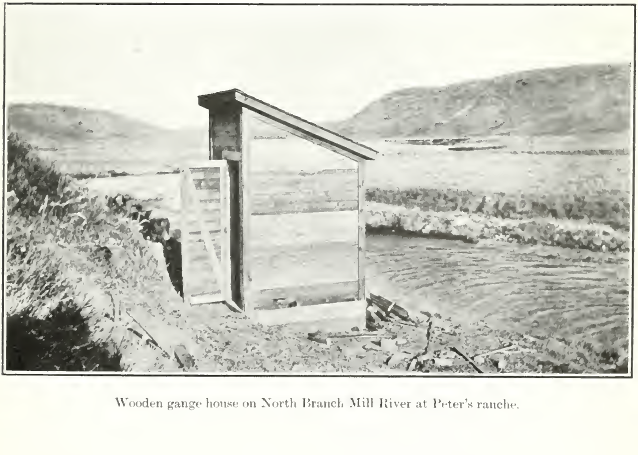
Gauging Station on Cascade River at Bankhead.

Reflection of the Vitoria Glacier in a small lake.



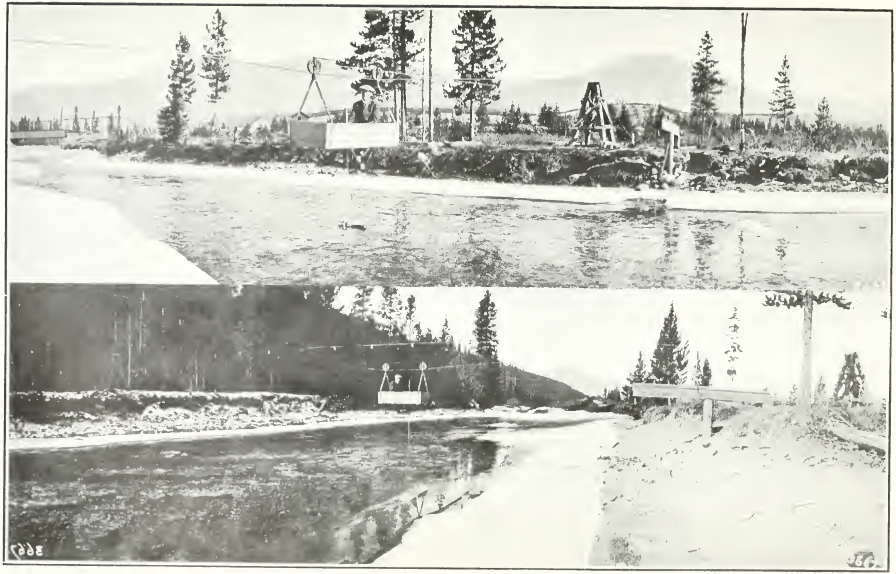
Concrete gauge house on St. Mary River, Kimball, Alta.

View of rating car, stationary.

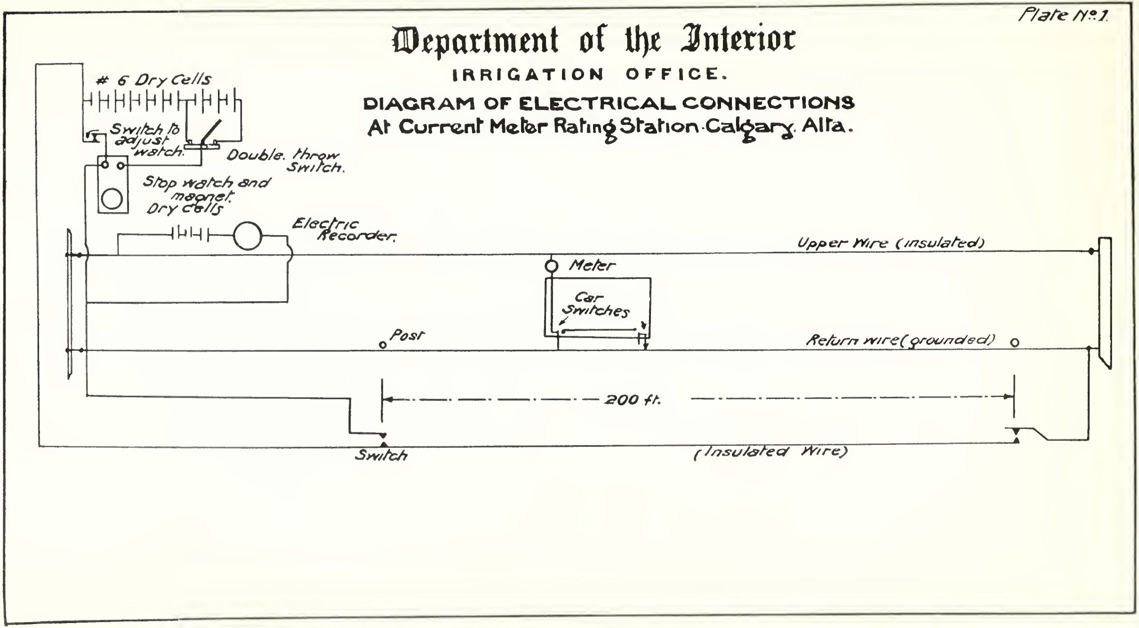


Wooden gauge house on North Branch Mill River at Peter's ranche.

A. Bridge over the Nort Saskatchewan River at Prince Albert.
B. C. P. R. bridge showing mass of ice created by flow of water from Lake Minnewanka taken near Banff.



A. Cable car and chain gauge on Pipestone River at Laggan. B. Cable car and chain gauge on Bow River at Laggan.



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PART VIII

WATER POWERS

No. 1.

REPORT OF THE SUPERINTENDENT OF WATER POWERS.

WATER POWER BRANCH,
April 1, 1913.

W. W. CORY, Esq., C.M.G.,
Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to submit the following short report of the work of the Water-Power Branch for the fiscal year 1912-13, and also the attached reports of the engineers in charge of divisions.

Much difficulty has been experienced during the past year in handling at Ottawa the increasing volume of business, necessitated by the great expansion of field work and by the activity in power development matters throughout the west, and it has been necessary to use members of the outside field staff for work at Ottawa for such time as it was possible to do so. This arrangement not only prevents the effecting of a permanent organization at Ottawa but to a very considerable degree decreased the efficiency of the permanent field organizations in the west. It is hoped the requirements for head office assistance will be met by the appointment, through the Civil Service Commission, of several additional technical clerks and draughtsmen. What is most urgently required is a capable and experienced correspondence and accounts clerk, a technical clerk and at least three draughtsmen.

Satisfactory progress has been made in all field work carried on under the direction of J. T. Johnston, B.A.Sc., hydraulic engineer of the branch. The hydrographic surveys in Manitoba and the Railway Belt of British Columbia have, so far as funds would permit, been extended and developed in an exceedingly gratifying manner. The report of the Chief Engineer of the Manitoba Hydrographic Survey, covering progress of stream measurement work under his direction, is in preparation at Winnipeg, but has been unavoidably delayed owing to special attention having to be paid to urgent field work incident to water-power matters, the regulation of the Lake of the Woods reference now before the International Joint Commission, and the special detail hydrographic surveys of the Red and Assiniboine rivers commenced in August, 1912, following a meeting of the Red River Navigation Association in Winnipeg in July. The report of the Chief Engineer of the Railway Belt Hydrographic surveys, covering the progress of stream measurement to date, is now ready to be printed, and will be published as soon as practicable. By the passage of a Bill amending the Railway Belt Water Act, 1912, now before the House, final and effective transfer of the administrative control over water rights in the Railway Belt of British Columbia to the crown in the right of the province will be consummated. This Bill excludes all present or future Dominion parks, within which the water remains under the administration of the Dominion. As this department must continue to have an indirect but active connection with the provincial water administration in the Railway Belt without the Dominion parks, and as the water matters in the parks require consideration, study and attention, it has been decided to continue as a permanent organization the Railway Belt Hydrographic Survey, with headquarters at Kamloops. In addition to this organization providing a ready means for Dominion co-operation and assistance to the provincial water administration, it affords the department an ever ready means

of securing technical reports on the many engineering matters that are continually arising in connection with the administration of land within the Railway Belt. Satisfactory co-operation has been effected with the superintendent of the British Columbia Lands Branch and the Dominion Parks Branch respecting the engineers of the Railway Belt Hydrographic Survey supplying any engineering advice or work that they may require. Arrangements have also been made with the Water Branch of the Department of Lands of the province of British Columbia for the co-operation of our engineers in water administration matters.

The extensive water-power investigations on the Bow river, commenced in 1911, with M. C. Hendry, B.A.Sc., engineer-in-charge, have been practically completed, and it is confidently expected that a full report of same will be ready for publication during this year. The general results of these investigations, as outlined in Mr. Hendry's report—Part No. 7 hereto—are surprisingly gratifying, showing that it is economically feasible to so regulate the flowage of the Bow river as to warrant the development at five power sites of over 45,000 continuous 24-hour wheel horse-power, all within a thirty mile reach of the Bow river and not more than fifty miles from the city of Calgary. The results of these investigations are an unanswerable argument in favour of similar investigations being carried on by competent experienced power engineers under proper expert advice. It is hoped that the results of these Bow river investigations and their value to the public will allow closer working co-operation to be effected with the irrigation engineers in similar investigations that may be made on Alberta streams, valuable for both irrigation and power purposes. The water-power engineers solicit and welcome the fullest co-operation of the irrigation engineers—their basic aims are identical and can only be properly and fully realized by co-operation. The present use and distribution, and the conservation of the water resources of the Bow river basin constitute one of the most important problems before this department. In some of its branches this problem has already been solved, while in others it still awaits solution, although a beginning has been made and the lines of progress have been marked out. The Bow river water seems so abundant that many persons do not reflect upon its importance, or the actual limits of the supply, yet this is of the utmost moment, for upon it depends the agricultural and commercial prosperity of a very large area of southern Alberta. Every one is familiar with the wonders that have been worked in this district by irrigation—miles of desert area, almost destitute of vegetation and incapable of adequately supporting human or animal life, have been converted by water from the Bow river into fertile tracts, producing an abundance of cereals and vegetables of all kinds. This has been due alone to the magic power of water, and to obtain it tremendous labour and many millions of dollars have been expended. With the growth of industrial activity the waters of this same river have also been called upon to supply energy for transmission, many miles away, to the city of Calgary, for municipal purposes, including street lighting, tramways, etc. At the first blush, it would appear as if these two important uses of water—for irrigation and for power—would result in a serious conflict of interests, but fortunately the irrigation requirements occur during a period that the river is in flood and storage on the upper waters of the Bow river will make it possible to conserve enough of the flood waters not required for irrigation to equalize the low flow during the winter months that may be required for power purposes.

The extensive power and storage investigations of the Winnipeg river have made considerable progress, but will not be completed for another year. The results of these investigations to date (as briefly outlined in Mr. Johnston's report, herewith) show that at six power sites on the Winnipeg river, within the province of Manitoba, over 239,000 24-hour continuous wheel horse-power can be developed, and with full regulation of the river (easily and cheaply accomplished by the Norman dam at the outlet of the lake of the Woods and by a dam at the outlet of Lac Seul) at least 500,300 horse-power of continuous 24-hour power can be developed. Surely this spells an assured industrial future for the city of Winnipeg and the province of Manitoba.

The investigations by Mr. H. E. M. Kensit, electro-mechanical engineer of this branch, into the power phase of the South Saskatchewan Water Supply Diversion Project, have been recently completed and will be published with as little delay as possible. Mr. Kensit's report is a valuable contribution to this most important project and places the power investigations of this department on a sound and reasonable basis. In view of the immensity of this project, the great engineering questions to be solved, and the enormous expenditure involved, it is considered that any further investigations should be carried on under competent expert experienced consulting advice. Mr. Kensit's report is published in full as an appendix, Part No. 12, of this report.

The investigations by Mr. Thomas H. Dunn, C.E., reclamation expert of this branch, during the seasons of 1911-12, of the extensive overflowed lands along the main Saskatchewan river between The Pas and Grand Rapids, Manitoba, have demonstrated the engineering feasibility of this reclamation scheme, and are so promising and of such public interest that his report is published in full as Part No. 11, herewith. Mr. Dunn will continue and complete his field investigations this coming season, chiefly with a view to demonstrating, by developing the engineering features sufficiently to enable him to prepare reliable cost data, the economic feasibility of his scheme of reclamation.

Advantage has been taken of Mr. Dunn's services to secure his opinion and advice on several other important reclamation projects that are before the department. Reclamation has already become a very important question with this department, and it would be in the best public interest if all reclamation matters were entrusted to a properly qualified technical officer. Mr. Dunn is pre-eminently fitted, from education and long experience in reclamation and drainage in Canada and California, for the responsibility.

The Coquitlam dam, under construction by the Vancouver Power Company at the outlet of Coquitlam lake, near Westminster Junction, B.C., will be completed early this summer, but the clearing operations around the lake will probably be carried on for some time to come, and may necessitate the continued presence of an inspecting officer. Mr. Stronach, resident inspecting engineer, and Mr. Johnston, both refer to this important and unique structure in their reports, herewith. In view of the dam being one of the largest and most notable hydraulic-fill dams on the continent, and the first in Canada, it is intended to prepare and publish a full account of the dam from its inception to completion.

At La Colle falls, on the North Saskatchewan river, work has been commenced by the city of Prince Albert on a 12,500 horse-power hydro-electric plant. This project offers some very interesting engineering features in that the type of dam selected is the Ambursen, and of an unusually bold design, after several conferences with prominent consulting engineers representing the department, the city of Prince Albert, the Ambursen Company and the chief engineer. A maximum flood discharge of 180,000 second-feet has been decided on by this branch as the amount for which discharging capacity must be provided. The provision for the passage of this flow called for considerable changes in the original design of the dam. Upon careful consideration it was deemed inadvisable, with the length of spillway available, to provide for this discharge wholly by overflow over the dam. Six submerged sluices operated from the interior of the dam have for this reason been incorporated in the design, and together with the overflow capacity available will provide for the passing of a flood of the dimensions named without damage to the structure or to existing interests. Plates Nos. 30 and 31 show the general features of the dam.

During 1912 the Calgary Power Company, Ltd., completed the construction of a storage dam at the outlet of lake Minnewanka, within the Rocky Mountains park, with capacity of 44,000 acre feet, in connection with as power developments on the Bow

river. On the initiative of this branch, advantage was taken to provide for possible future power project for park purposes by having all necessary permanent works for a power intake incorporated in the dam. Careful surveys and investigations by engineers of this branch have proved the feasibility of a commercially economic development of an 1,800 horse-power hydro-electric project in conjunction with the dam, for the purpose of supplying power over a transmission line to the town of Banff and to enable the Dominion Parks Branch to suitably supply the town with the usual public utilities and to develop the lighting of the Canadian National Park along modern and approved practice. The preliminary report by Mr. C. H. Mitchell, C.E., consulting engineer to the branch, on this Cascade River power project is published as Part No. 8 herewith. Messrs. C. H. and P. H. Mitchell are collaborating with engineers of this branch in working out a full and complete design and specifications of this project in order that everything may be ready for the calling of tenders during the summer of 1914.

The policy of this department with regard to the conservation and development of the water-powers under its jurisdiction in Manitoba, Saskatchewan, Alberta, the Railway Belt of British Columbia and the Northwest Territory, has been of gradual growth, although each step has led in the same general direction—actual development without delay, control of rates to be charged consumers of power, and a rental for the use of the power, with the right to revise same. As water-powers are valuable because of their strategic position, as well as because of the flow and fall of the water, and as their adequate development generally means a very large expenditure, the means whereby the priority of right to any given power is established is a very important feature of any regulations concerning them. In this connection the principle is laid down that mere priority of application does not establish priority of right. Priority is only secured when an agreement under the water-power regulations has been entered into between the Department and the applicant for the development of the power. The agreement provides for the development of a minimum amount of power within a fixed period, not exceeding five years, for the expenditure of a stated amount of money on actual developments operations in each year, and for the issuance of a license covering the necessary amount of water and a lease for the necessary Dominion land upon the fulfilment of the terms of the agreement, the lease and license to be concurrent and for a term of twenty-one years, renewable for three further consecutive periods of twenty-one years each, and subject to cancellation upon non-fulfilment of the terms of the lease and license.

Under the present water-power regulations it has been extremely difficult to deal with applications for the development of small power projects, but regulations will shortly be in force covering small water-powers of less capacity than 200 horse-power, and it is proposed to have an experienced practical engineer make a full personal investigation of each application for the right to develop these small power schemes, with a view to rendering such engineering assistance and advice as may be possible. Most of these are projected by settlers and small mill owners, with a view to developing sufficient power to run a grist-mill or saw-mill, or for general lighting and farm purposes. In view of the practical adaptation in Ontario and the state of New York, of electricity for general labour-saving devices around the farm and for small manufacturing purposes, it would surely be a direct and lasting benefit if proper practical advice and experience were made available by the Government in connection with the many small projects throughout the West which are before this department for authorization. To meet the situation, Mr. A. M. Beale, B.Sc., an engineer of this branch, has been delegated to give this matter his special study and attention. Mr. Beale will, wherever practicable, inspect each application, and where necessary will give the applicant every possible assistance in having the project carried out in a satisfactory way. Mr. Beale's report, Part No. 3 herewith, on small water-powers, is of great interest.

In most of the power applications that have been before the department, and in all that have resulted in any agreement being issued under the water-power regulations,

important matters have arisen as to the stability of structure, and in the investigations that have ensued the necessity has repeatedly arisen for the co-operative assistance of a skillful and experienced geologist, whose superior insight into underground conditions would be of the utmost value in reaching safe and economic conclusions. While not every geologist can grasp the engineer's point of view and appreciate just what line of inquiry would yield the most important engineering results, it is thought that the necessary point of view could be gradually developed if it were possible to make a permanent arrangement for the continuous co-operation of a geologist in the employment of the Dominion Government. It is hoped that it will be possible to effect satisfactory arrangements to this end with the Director of the Canadian Geological Survey.

During the past year several separate reports have been prepared for publication, and it has been considered desirable to adopt some general title to simplify indexing and to group all publications issued from this branch. The general title adopted is that of 'Water Resources Paper No. ....,' following the precedent of the United States Geological Survey branch in dealing with hydraulic work.

In conclusion, I would state that the fiscal year just ended has witnessed a most successful and satisfactory development of the field and administrative work of the branch.

I have the honour to be, Sir.

Your obedient servant.

J. B. CHALLIES,
Superintendent.

No. 2.

REPORT OF B. E. NORRISH.

OFFICE OF CHIEF DRAUGHTSMAN,
March 31, 1913.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water-power Branch.
Ottawa.

SIR,—I beg to submit the following brief statement of the work of this office for the fiscal year 1912-13.

The draughting work at Ottawa in connection with the regular routine work of the branch has increased enormously in recent months, necessitating the immediate addition to the staff of at least two experienced draughtsmen, and a clerk-draughtsman qualified to index, file and keep track of the several hundred plans which have already accumulated and which are rapidly increasing. Some of these plans represent many thousands of dollars expenditure in field investigations and many others are of great official and legal value. As they are all in constant and frequent use they must be readily available at all times. In addition to proper personal responsibility for these plans, some adequate filing apparatus must be obtained. In the space at present available it is impossible to accommodate either filing apparatus or draughtsmen and I would urge your further action towards obtaining suitable space for this purpose in the addition now completed in the Union Bank building adjoining our present quarters.

In addition to the regular draughtsmen I have had to accommodate throughout the winter months six engineer-draughtsmen of Mr. Hendry's Bow river power and storage investigations staff. The same necessity will arise next winter.

Your particular attention is called to the advisability of having a complete set of negatives of all plans of the branch stored in some fireproof vault in another building.

The administration by this branch of foreshore, and land under water generally, in Manitoba, Saskatchewan, Alberta and the Railway Belt of British Columbia has not been satisfactory on account of the fact that other branches are dealing with similar matters. A definite departmental ruling ought to be secured at once, in order that there may be no doubt whatever as to this branch's responsibility for such matters.

I have the honour to be, Sir,
Your obedient servant,

B. E. NORRISH,
Chief Draughtsman.

No. 3.

REPORT OF A. M. BEALE.

SMALL WATER POWERS.

OTTAWA, March 31, 1913.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water-power Branch,
Ottawa.

SIR,—I beg to submit the following statement with regard to the small water-powers under the jurisdiction of this branch.

In June, 1911, Mr. B. E. Norrish, M.Sc., made inspections of some thirteen small powers for which there were applications before the department. In his report, Mr. Norrish recommended that some simple means of authorizing these schemes and others of similar nature be provided in the regulations. The existing water-power regulations, though quite satisfactory in dealing with larger projects, entail an expense which would be prohibitive to any individual who proposes to install a power of 150 horse-power or less, for purely local purposes.

An amendment to the regulations in the form of a new clause has been prepared and is as follows:—

'*Small water-powers of less capacity than 200 horse-power.*

'(12) If upon receipt and consideration of the information set out in sections 2, 3, 4 and 5, the water-power to be developed is found to have no greater capacity than 200 horse-power at the average low stage of water, the Minister may issue a lease and a license, as may be required, authorizing the development of the proposed power; the lease and license to be for a period of ten years, subject to such special terms and conditions as may be considered advisable in each particular case, and renewable if in the opinion of the Minister the power has been continuously and beneficially used.'

It is to be hoped that this amendment will be added to the regulations as soon as possible so that the projects which are before the department will no longer be delayed.

Small water-powers merit considerably more attention than has been accorded to them in this country. In Great Britain the water-driven mill is to be seen on every hand in the country districts, flour and feed mills, saw-mills, pin-mills and so forth, furnish a local industry for the supply of local wants. In Canada the conditions are vastly different, but in Eastern Canada and the United States, where conditions approximate more nearly to those of the western provinces, these small power sources are receiving attention.

It is of interest to mention here that the form of water-motor most used in England for small power purposes is the overshot wheel. This wheel is shown by Mr. C. R. Weidner, of the University of Wisconsin, to be peculiarily suitable for small powers on this continent, ranging in head from 10 to 40 feet and from 2 to 30 second feet in discharge, that is to say, up to 75 horse-power. These wheels, though nearly twice as costly as turbines of the same power, have the advantage of high efficiency, reliability, adaptability to varying discharge, simplicity in construction, setting and operation, all of which compensate for an increased initial cost; further, ice troubles experienced with this form of wheel are less severe. For the development of small powers, and especially for driving slow speed machinery, the overshot wheel is worthy of attention.

The Conservation Commission of the state of New York has recently issued a pamphlet by David R. Cooper, entitled 'Water-power for the Farm and Country Home'; this is designed to point out the possibilities for small water-powers in the state of New York so that farmers and residents in rural districts may take advantage of them. To quote:—

> 'The Commission desires to call attention to the valuable power which is now running to waste in thousands of small creeks and brooks in all sections of the state. Many of these minor streams present possibilities for small individual development of power sufficient to supply all the requirements of the owner at a comparatively small cost. Numerous farms in the state have on them brooks or creeks capable of supplying power sufficient to furnish electric light for all the buildings. Others would also furnish power enough to drive a feed grinder, a churn or cream separator, or to run a wood saw, sewing machine or other machines and implements requiring a small amount of power for their operation. In short, there are numerous small streams now tumbling over ledges in barnyards or pastures whose wasted energy might readily be transformed and applied to useful work by the installation of small and inexpensive water-power plants. If the power of more of these was developed and substituted for manual labour, a great saving of time and energy would be accomplished, and financial profit would result.'

This paper goes on to describe certain typical plants that have been installed; a singularly efficient plant of 17 horse-power which supplied energy to the farm for nearly every purpose is estimated to have cost $1,800. At another farm a 4 horse-power outfit cost the farmer $520, exclusive of his own time.

The following list, taken from the same publication, gives an idea of the power necessary for certain operations:—

> 'Six horse-power will drive a grain separator and thresh 2,500 bushels of oats in ten hours.
>
> 'Three horse-power furnishes all power needed to make 6,000 pounds of milk into cheese in one day.
>
> 'Six horse-power will run a feed mill grinding twenty bushels of corn an hour.
>
> 'Five horse-power grinds twenty-five to forty bushels of feed, or ten to twelve bushels of ear corn, an hour.

'Seven horse-power drives an eighteen-inch separator, burr mill and corn and cob crusher and corn sheller, grinding from twelve to fifteen bushels of feed an hour, and five to eight bushels of good, fine meal.

'Six horse-power runs a heavy apple grater, grinding and pressing 200 to 250 bushels of apples an hour.

'Five horse-power will drive a thirty-inch circular saw, sawing from fifty to seventy-five cords of stovewood from hard oak in ten hours.

'Six horse-power saws all the wood four men can pile in cords.

'Twelve horse-power will drive a fifty-inch circular saw, sawing 4,000 feet of oak, or 5,000 feet of poplar, in a day.

'Ten horse-power will run a sixteen-inch ensilage cutter and blower, and elevate the ensilage into a silo thirty feet high at the rate of seven tons per hour.

'One horse-power will pump water from a well of ordinary depth in sufficient quantity to supply an ordinary farmhouse and all the buildings with water for all the ordinary uses.'

The Hydro-Electric Power Commission of Ontario in connection with their rural business have made a study of the application of electric power to farm uses, and have made a series of demonstrations to farmers themselves.

In the Fifth Annual Report of this Commission there is much interesting information to be found. We find a comparison of a 25 horse-power steam threshing outfit with an electrically operated one of the same power; this, however, cannot be applied here since the cost of purchasing and operating a steam plant will depend on the locality, and the cost of a small water-power development will vary with every individual case.

There is, however, much information as to the quantity of power required for various operations, and any individual contemplating a development would do well to study this report.

In Ontario, Quebec, New Brunswick and Nova Scotia, according to figures given by the Conservation Commission, there are in all some 300 water-powers developed, which would come within the limits set in this discussion; these are used largely for mill purposes direct and are not hydro-electric, particulars are not available but an inspection of a few selected ones should supply much valuable information for study of this nature.

While it is advisable to stimulate interest and promote the development of water-powers that will prove an economic success it is even more necessary to prevent any waste of time and money by an ill-advised attempt to obtain power. This variety of power, unlike steam, gas or other engines, requires but little attention, a very good feature where labour is expensive. The following points, however, have to be considered:—

1. Whether there is sufficient water all the year round to drive the turbine.

2. Whether ice troubles in winter are liable to block the flow and cause a jam, cutting off the power and endangering the dam.

3. Whether floods are likely to occur and whether there is provision for sufficient discharge.

4. Whether undue flooding will occur if a dam is constructed, whether the dam will be cheap and stable, and whether the transmission line will be short. Briefly —will the plant provide power all the year round at a cost small enough to compete with other sources of power and without changing the local natural conditions to an extent detrimental to the interests of existing or future neighbours.

The average person desiring to utilize such a power is usually unqualified to judge of its feasibility, while the undertaking is not of sufficient magnitude to warrant employing an engineer, it is therefore desirable that an early and careful

inspection be made by a technical officer of the department of every site for which an application is received; this official should be instructed to give the applicant the benefit of his technical advice, as well as report to his superiors on the advisability of granting a license for the development.

I beg to recommend that a careful investigation of the subject of small powers be commenced by studying technical literature, and by inspecting existing plants; a report on the whole question should then be prepared with data showing the best forms of development and machinery for different conditions, costs of machinery, also costs of competing powers, amounts of power required for various operations. Such a report should prove of sufficient interest for general distribution, and of considerable value to the prospective small water-power user.

I would further suggest that, until a fixed policy can be formulated, no small water-power privileges be given without an inspection by a technical officer of this department.

I have the honour to be, Sir,
Your obedient servant,

A. M. BEALE,
Engineer.

No. 4.

REPORT OF J. T. JOHNSTON.

April 1, 1913.

J. B. Challies, Esq., C.E.,
Superintendent, Water-power Branch,
Ottawa.

Sir,—I have the honour to submit herewith the following report regarding the field organization and the general work carried on under the jurisdiction of the Water-power Branch during the past year.

STAFF.

The technical field staff of the branch consists of:—

Manitoba Hydrographic and Power Surveys.

Chief Engineer	D. L. McLean, B.Sc.
Ass't. Chief Engineer	S. S. Scovil, B.Sc.
Assistant Engineer	G. H. Burnham, B.A.Sc.
" "	E. B. Patterson, to Dec. 13, 1912.
" "	S. C. O'Grady, B.Sc., from July 10, 1912.
" "	A. E. W. Hanington, B.Sc., from March 19, 1913.
" "	A Pirie.
Jr. Assistant Engineer	H. M. Nelson, from May 20, 1912.
Draughtsman	P. J. Barry.
" "	A. P. Smith, from March 13, 1913.

Temporary Assistance on Red River Surveys.

Assistant Engineer	W. W. Buchanan, B.E., July 28 to Dec. 31, 1912.
" "	B. H. Hughes, July 28 to Dec. 31, 1912.
" "	W. G. Worden, B. Sc., July 30 to Dec. 31, 1912.
" "	D. Cameron, Aug. 10 to Feb. 3, 1913.
" "	H. J. Woodman, July 31 to Feb. 9, 1913.
" "	G. J. Lamb, from Sept. 12; made permanent Mar. 19, 1913.
" "	R. H. Nelson, from Sept. 16.
Draughtsman	E. B. Chalmers, from Aug. 7; made permanent Jan. 1, 1913.
Jr. Assistant Engineer	A. M. Reid, July 28 to Dec 3.

Railway Belt Hydrographic Survey.

Chief Engineer.................... P. A. Carson, B.A., D.L.S.
Assistant Engineer................ C. G. Cline, B.A.Sc., D.L.S.
" " .... C. E. Richardson, B.A.Sc.
" " .... E. M. Dann, D.L.S., Grad. S.P.S.
" " .... H. J. Keys, B.A.
Jr. Assistant Engineer............B. Corbould, May 26 to Sept. 16, 1912.
" " .... H. C. Hughes, May 13 to Aug. 17, 1912.
Stenographer......................Miss B. Allan, from May 30.

Bow River Power and Storage Surveys.

Chief Engineer.................... M. C. Hendry, B.A.Sc.
Assistant Engineer................C. H. Attwood, O.L.S., May 8 to Oct. 10, 1912.
" " .... K. H. Smith, B.A.
" " .... D. B. Gow, B.Sc., from May 8, 1912.
Jr. Assistant Engineer............C. P. Cotton, May 8 to Oct. 1, 1912.
" " .... E. R. Dafoe, May 8 to Oct. 1, 1912.
" " .... B. B. Hogarth, April 26 to Oct. 10, 1912.

Construction.

(a) Coquitlam Dam—
Inspecting Engineer........... R. S. Stronach.
Clerical Assistant.............. A. T. Milner.

(b) La Colle Falls Power Plant—
Inspecting Engineer........... E. B. Patterson. from Dec. 13. 1912.

(c) Minnewanka Dam—
Inspecting Engineer........... K. H. Smith, B.A.

Dominion Land Surveys.

Chief.............................. Wm. Ogilvie, D.L.S.
Assistant.......................... J. D. Gardner, May 13 to Oct. 21, 1912.

Reclamation.

Chief Engineer....................T. H. Dunn, C. E., O.L.S.
Assistant Engineer................ O. W. N. Charlton, B.A.Sc., from July 25, 1912.

South Saskatchewan Water Supply Diversion Project.

H. E. M. Kensit, Mem. Inst. E.E., Mem. Am. I.E.E.

Board of Consulting Engineers.

J. R. Freeman, C.E., Providence, R.I.
C. H. Mitchell, C.E., Toronto.
J. B. McRae, C. E., Ottawa.

HYDROGRAPHIC SURVEYS.

Railway Belt Hydrographic Survey.

Hydrographic survey work in the Railway Belt of British Columbia has been continued throughout the year under the chief engineer, Mr. P. A. Carson, assisted by an efficient staff of engineers, with headquarters at Kamloops. The scope of the work has been enlarged until the whole belt has been fairly thoroughly covered, as is shown by Plate 1. The attached summary report by Mr. Carson gives, in detail, the field work carried on under his direction. During the past few months he has made every effort to compile all stream flow records for a complete report, which is to be published shortly, and will contain a complete résumé of all the stream measurement work which has been undertaken under Mr. Carson's direction since the organization of the work in April, 1911, and will also incorporate all previously existing records which are reliable.

During the coming season the work should be continued aggressively, stations being established at all possible points where records may be of future use.

Manitoba Hydrographic Survey.

This work which D. L. McLean, B.Sc., the chief engineer, inaugurated in the spring of 1912, has been vigorously prosecuted and now covers the main rivers and streams in the settled portions of the province (see Plate 2. The Winnipeg and the Saskatchewan rivers are of pressing importance for power purposes, and the continuous record of their flow is of the utmost value; special attention has been and will be given to these two rivers. The rivers finding their entrance into Lake Winnipeg along its eastern shore are difficult of access, but are important for power, and it is hoped that during the coming season the securing of a record of their flow can be commenced.

Evaporation Stations.

The advisability of studying the evaporation conditions in the Winnipeg River basin in connection with the power question and in relation to general stream flow has been recognized for some time, and preparations are now under way for the establishment of a fully-equipped station on the Lake of the Woods, the equipment of which is listed in Mr. McLean's report. The advisability of establishing further stations of less elaborate description in various parts of Manitoba is pointed out, and the installation for these stations should, if possible, be secured at once and the establishment of the stations proceeded with during the coming season. The information obtained will be especially useful in connection with questions of water supply.

Staff Gauges.

The enamelled gauges which were introduced by Mr. Carson in connection with the Railway Belt work have been in use since August last. These gauges have blue enamelled markings on a white ground and are illustrated in the accompanying photos. The gauges have scarcely been long enough in use to test their durability, but they have so far given every satisfaction. Their principal advantages are lightness, ease of reading, and cheapness, the cost of each three-foot length being about 60 cents. which compares favourably with the cost of an ordinary hand-painted wooden gauge.

Underground Water Supply.

A study of the underground waters of Manitoba is brought to your attention by Mr. McLean. This is a question of the utmost importance to all parts of the province, but most especially where the surface water is deficient. The advantages of the systematic study, outlined by Mr. McLean, are obvious, and his organization is best fitted to secure the information and to economically carry on the work.

Gazetteer of Streams and Data.

In connection with the hydrographic work in Western Canada the advisability of issuing a complete and systematic gazetteer of all the streams which have been studied is brought to your attention. In the detailed study which the various field officers of the Government give to the rivers and streams which come within the scope of their operations, a great deal of very valuable data are collected, which should not only not be lost, but should be made readily available to the public.

Automatic Gauges.

Automatic gauges could be used to great advantage in connection with some of the metering stations in Manitoba. The cable station at Slave falls on the Winnipeg river is difficult of access, and the only gauge to which it can be referenced

is affected by the discharge through the power stations of the city of Winnipeg at Point du Bois. An automatic gauge is necessary at this point, as a reliable record of the Winnipeg river flow is based on this station. An automatic gauge could also be advantageously used on the Lake of the Woods.

Snow Surveys for Predicting Stream Flow.

Your attention is called to the snow surveys for the purpose of predicting stream flow, which have been carried on during recent years, in the irrigation districts of Utah, in the United States. By means of careful observations of the snow depth, density, and water equivalents in the head-water regions of streams utilized for irrigation, it has been found possible to foretell with reasonable accuracy the flow which may be anticipated during the succeeding season. Information of this nature is of the utmost value to water users, especially to those interested in streams that are fully appropriated, and enables the irrigator to lay out his season's operations with a certain amount of definiteness and assurance. It would be advisable to inquire carefully into the methods adopted and results obtained in such survey work, with a view to ascertaining their utility, more especially in the irrigation districts of the Railway Belt.

POWER SURVEYS.

Grand Rapids on the Saskatchewan.

The transfer of the water-power party in charge of Mr. E. B. Patterson, to the Grand Rapids on the Saskatchewan river, was necessary in order that the department might have first-hand information respecting that important power site. The work of the party is covered in Mr. McLean's report, and the plans covering the surveys have been forwarded to this office; a detailed study of the power possibilities and best method of development will be proceeded with. It was intended that the power party should, after the completion of the Grand Rapids work, be placed at the disposal of Mr. Dunn in connection with the detail work required in the Pasquia reclamation scheme, but the shortness of the season, combined with the amount of work necessary at Grand Rapids, prevented any work being done on the reclamation scheme, and the party returned to complete the work on the Winnipeg river.

Southern Manitoba.

Numerous applications have been received for power privileges throughout Manitoba, and Mr. McLean has inspected and reported on these from time to time during the past season. Certain of the powers thus reported on were of sufficient importance to warrant a fairly extensive investigation; the Manigotagan river was one of these, and the reconnaissance work performed thereon showed the advisability of a further investigation in the upper waters ,and an investigation which is intended to cover all the power, as well as storage possibilities, is projected for the coming season; the work will be of a reconnaissance and consequently inexpensive nature, but will supply the information which is necessary to deal to the best advantage with the powers on the river.

The municipality of Brandon has requested that the department make an investigation of the Assiniboine and Little Saskatchewan rivers in the interests of power, and arrangements are being made to have this work carried out during the next season. The survey will, like that of the Manigotagan, be of a reconnaissance nature, as the discharge of the river does not at this stage warrant more, but it will be sufficient to ascertain the power resources of the river, and also what is involved in the development of any possible sites.

Other rivers which are marked out and appear worthy of study are the Dauphin, Waterhen, Mossy and Valley, and it is the intention to keep a second power party, in

addition to that on the Winnipeg river, at work throughout the season, examining the most promising power rivers in southern Manitoba, so that as much ground as possible will be covered.

The enormous resources of the Nelson river form the natural power storehouse of northern Manitoba. This river receives the run-off of the Winnipeg, Red, Saskatchewan, and innumerable smaller rivers; the whole run-off is equalized by the three large lakes, Winnipeg, Winnipegosis and Manitoba; the drop of 710 feet from lake Winnipeg to Hudson bay, over a series of falls and rapids, offers an enormous source of power for this district. The rapid opening up of the country due to the building of the Hudson Bay railroad will soon bring these powers within the range of commercial development, and it would be advisable that an investigation of the river be kept in view. The Churchill river further to the north also offers a great field for power development.

Bow River.

The Bow River power and storage investigations, with Mr. M. C. Hendry as chief engineer in the field, were continued and completed. Mr. Hendry's report covering this and other work which was undertaken by him is attached. The services of Mr. C. H. Mitchell, consulting engineer of Toronto, were continued throughout the year in connection with certain features of design in the Bow river and Minnewanka storage work. Upon the completion of the field work at the end of the season, Mr. Hendry, together with Assistant Engineers Smith, Gow, Attwood and Hogarth, returned to head office, and the winter season was devoted to the reduction, plotting and compiling of the field notes and to preparing a report on the whole power and storage situation for publication. Mr. Hendry's preliminary summary report gives, in the main, the general features of the conclusions which have been reached, but these may be slightly revised before being finally published.

Elbow River.

No additional field work was done on the Elbow river during the past season. The results of the previous seasons have been brought up to date, and are noted in Mr. Hendry's report. The Elbow river data will form a portion of the Bow River report.

Grand Rapids on Athabaska.

Mr. C. H. Attwood, with a small party, was detached from the main Bow River party in August, and sent down the Athabaska river to secure reliable data with respect to the Grand rapids on that river. This survey was completed and the party returned to Edmonton early in September, and a full record of the general features of the site is incorporated in Mr. Hendry's report.

POWER APPLICATIONS REPORTED ON BY MR. HENDRY.

Among other inspections and reports made by Mr. Hendry during the season, the following are the most important:—

The town of Fort Saskatchewan constructed on the Sturgeon river a small hydroelectric plant for local use. No authority had been secured by the town from the department for the construction of the plant, and no plans submitted for approval. In April the head works of the canal failed and the canal and wheel chamber were washed out. Mr. Hendry was instructed to visit the site and report on the cause of failure. His recommendations as to the rebuilding were transmitted to the municipality, but to date no action has been taken towards repairing the break.

Applications for power at Rocky rapids on the Saskatchewan river, and on the McLeod river near Edson, were also received and reported on and are covered in Mr. Hendry's report.

Surveys Recommended.

During the coming season the following power investigations in the province of Alberta are considered advisable and are recommended for Mr. Hendry's attention:—

(1.) A reconnaissance of the Athabaska river from Athabaska Landing to Grand rapids for the purpose of ascertaining the possibility of profitable power development.

(2.) A reconnaissance of the Athabaska river from Athabaska Landing up to the mouth of the Lesser Slave river and up this river to Lesser Slave lake.

(3.) A reconnaissance of the Lesser Slave lake with a view to its use as a storage basin.

(4.) A reconnaissance of Lac la Biche and Calling lake with a view to their use as storage basins.

(5.) A reconnaissance of Jasper and Brulé lakes on the Athabaska river with a view to storage.

(6.) If time permits, a reconnaissance of the Athabaska river below Grand rapids down to the mouth of Clearwater river and up the latter, making inspections of all power possibilities; also a reconnaissance of the Beaver river.

(7.) Inspections of the various power sites now applied for on the upper waters of the Athabaska river, and on the Stoney, the Embarrass, and the Brazeau rivers.

(8.) Inspection of the power conditions on the Sturgeon and Red Deer rivers.

(9.) Power reconnaissance of the Spray river.

WATER-POWER AND STORAGE INVESTIGATIONS.

Winnipeg River.

The inception of the Winnipeg River power and storage surveys was briefly dealt with in the last annual report. The continuation and progress of these surveys is covered by the report of Mr. D. L. McLean, engineer in charge of the field investigations. As the Winnipeg River party was transferred during July, August and September, to the Grand Rapids on the Saskatchewan river, for the purpose of carrying on a similar survey of that site, the Winnipeg river work will not be completed until some time during the coming season; sufficient has been done, however, to permit preliminary conclusions to be reached as to the best method of using the various falls of the river. The substance of these preliminary conclusions is given herewith, but is subject to revision upon the final completion and consideration of all the field work.

A full report on the power and storage investigation on the Winnipeg river will be published as soon as the present surveys are completed and as soon as the additional data now being collected are collated and studied.

While the Water-power Branch is concerned only with the powers in Manitoba, it has nevertheless been necessary to make a careful investigation of the upper waters of the Winnipeg River basin, in the province of Ontario, with a view to ascertaining the storage resources of the river. This will also be fully covered in the above-mentioned report.

Object of the Power Study.

It has been considered that, although the time may be somewhat distant at which all the power resources of the Winnipeg river will be utilized for commercial purposes, the policy to be followed by the department in the power administration should be the

maximum utilization to the best possible advantage of all the available power in the river. The object, therefore, of the investigations is to secure sufficient information to enable a complete scheme of development for the whole river to be worked out, so that no wasteful development will occur, and no portion of the head shall be left unutilized. When these considerations have been finally determined, the department will be in a position to authorize and dictate developments which shall fulfil the required conditions.

The question and possibility of the future navigation of the river has been kept constantly in view, and in all developments proposed, and layouts considered, provision has been made for the subsequent inclusion of a lock and approaches. As it is the intention, so far as possible, that the head-water of one development shall be the tail-water of the next above, allowing for the necessary hydraulic gradient of the river, the future addition of these locks will insure a fairly complete system of navigation at lit^1 further expenditure.

River Basin and Run-off.

The Winnipeg river, in its natural condition, forms one of the best regulated rivers on the continent. It drains an area of 53,000 square miles, the larger part of which is still in a state of nature. The upper portion of the basin (Plate 4) is filled with innumerable lakes of every size up to that of the Lake of the Woods with its 1,500 square miles of water surface. Among other large lakes which form this system of natural storage basins are Rainy lake, lake Namakin, Lac Seul and Trout lake, the result being that in a normal year the range of variation in the discharge of the river is only from 15,000 to 45,000 second feet between low and high flow; in extreme years these limits may be changed to 12,000 and 80,000 second feet, respectively. No actual measurements have been obtained of maximum floods in the records which have been secured during the past five years, though high-water marks, distinctly indicated on the rocks along the river do conclusively show that flood conditions of this extent have occurred.

The records of flow of the Winnipeg river extend back to the beginning of 1907, the early measurements being recorded by the Winnipeg Electric Railway Co., and the city of Winnipeg, in connection with their plants on the river. A cable station was established in October, 1911, just above Slave Falls, by the Power Survey party, at what was judged to be the best available location on the whole river; constant measurements have been taken since that date, first by the Power party, and latterly by the staff of the Hydrographic Survey of Manitoba.

It would be well to point out that the measurements which have been obtained recently have shown that the minimum flow is much less than it was considered a few years ago. When construction was first considered in connection with the city plant at Point du Bois, the minimum flow was generally considered to be about 20,000 second feet, and the city plant, when completed as now laid out, will accommodate, at full load, at least that amount.

The actual gaugings of the river have shown a minimum flow of 12,000 second feet on March 27, 1911, and a maximum of 52,700 second feet taking place on May 19, 1910, which shows at once the necessity for storage in the upper reaches, if full benefit is to be derived from the power latent in the river.

The average run-off from the river at Slave falls for the past five years has been 26,368 second feet; this includes two successive years of unusually low water. It is intended that a close detailed study will be made of the storage possibilities of the whole basin, and it is hoped that when records are to hand covering a complete cycle, that the above average may be raised and that, owing to the unusual natural facilities, a complete system of storage may possibly supply a uniform run-off of 25,000 second feet.

Lake of the Woods as a Storage Basin.

Lake of the Woods is the largest and most important of these bodies of water and also, from its natural advantages of location, forms the most obvious storage reservoir in the system. The question of the regulation of the surface level of the lake has become international, due to the flooding of certain low-lying lands along the southern shore of the lake in the state of Minnesota, and the Water-power branch, being vitally interested therein on account of the direct connection of the lake with the water powers of the Winnipeg river, is making a careful investigation into its storage capacities and the benefit to the powers of the lower river to be derived therefrom. When the full data which are now being secured are complete, the exact relation of the lake to the power system can be fully discussed. In the meantime sufficient is to hand to warrant the following statements:

1. The use of the Lake of the Woods as a storage basin is essential to the full conservation scheme which it is hoped will ultimately be worked out on the Winnipeg river.

2. The low-water conditions on the river in the winter season, as disclosed by meterings during recent years, show the necessity for storage provision in the immediate future in the interests of present plants.

3. The obvious advantages of the lake mark it out as the place where regulation should take place. These advantages are both natural and artificial, and are in the main as follows:—

(*a*) The lake is at the head of a total drop of 341 feet between itself and lake Winnipeg, 291 feet of which can be utilized for power purposes.

(*b*) It receives the run-off from 25,000 square miles of territory.

(*c*) It has an area of 1,500 square miles of water surface, practically sufficient to store the whole surplus run-off of the basin above, and to render the flow from its outlets uniform throughout the year and from year to year, were 9 feet of storage permissible. If full use is made of the storage opportunities in Rainy lake, lake Namakin and other lakes in the basin above, storage on lake of the Woods to this depth will not be necessary to insure uniform run-off.

(*d*) The three outlets are already artificially controlled, one by the stoplog controlled Norman dam with 21 sluices, which, with relatively inexpensive repairs, could be used to perfectly regulate the lake.

4. By a complete conservation of all the waters entering the lake, the run-off from its outlets will be increased by about 140 per cent over past minimum flow conditions.

5. The power available in the river below the junction with the English river, i. e., in Manitoba, will be increased about 58 per cent over that available during present minimum flow conditions.

6. The total power available on the river from the Lake of the Woods will be increased about 68 per cent, i. e., from 276,100 horse-power to 464,400 horse-power.

7. In the past eight years the water surface of the lake has varied in elevation more than five feet under existing conditions. Previous to the construction of the power plants and dams at the outlets from the lake, the surface level varied in elevation from 10 to 12 feet.

The result of the storage investigation to date tends to the certainty that a uniform flow of 20,000 second feet can be assured on the river, and to the belief that a flow of 25,000 is a possibility in the future.

In this connection the table here given is of interest; this table was prepared by Mr. D. L. McLean, chief engineer of the Winnipeg River power and storage surveys,

with the view of roughly illustrating the possibilities for storage in this basin. With the exception of the Lake of the Woods, Rainy lake and lake Namakin no actual investigations on the ground have been made, so that the information tabulated cannot be considered as anything more than approximate.

The data tabulated are based on an average annual run-off of 6·5 inches over the whole watershed. This is warranted by the run-off records which are on hand for the past five years. The areas in columns 3 and 5 have been taken from the best existing departmental maps. Column 8 gives the depth in feet on each reservoir necessary to hold the total run-off of its basin for one year. Columns 9 and 10 list the storage which might be obtained on each lake were a storage to the depth of 5 feet permissible.

TABLE showing Storage Possibilities in Upper Winnipeg River Drainage Basin.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Reservoir.	Drainage Basin.		Run-off.		Area of Reservoir.		Depth of Storage to Hold Runoff for 1 year.	Storage.		Remarks.
	Sq. Miles.	Acres.	Mile Feet per An :	Acre Feet per An ;	Sq. Miles	Acres.		Mile Feet 5ft Storage.	Acre Feet 5ft Storage.	
Lake of the Woods..	24902	15,937,280	13489	8,632,960	1500·00	960,000	9	7500	4,800,000	
Dogtooth......... ..	127·5	81,600	69·20	44,288	12·75	8,160	5·4	63·8	40,832	
Berry........	286	183,040	155	99,200	4·99	3,194	31·1	24·9	15,936	
Dayberry...........	248	158,720	134·50	86,080	41·10	26,304	3·3	134·5*	86,080	*3·3 ft. Storage.
Whitefish...	791	506,240	429	274,560	21·80†	13,952	19·7	109	69,760	† { Whitefish 8·10. Sturgeon 13·70.
Atikwa	196	125,440	106·20	67,968	21·18	13,555	5	106·2	67,968	
Kakagi.............	123	78,720	66·60	42,604	43·60	27,904	1·5	66·6*	42,604	*1·5 ft. Storage.
Denmark..... ..	330	211,200	179	114.560	2·49	1,594	71·9	12·4	7,936	
Rowan..............	320	204,800	173·50	111,040	23·68	15,155	7·3	118·4	75,776	
Cameron....	27	17,280	14·60	9,344	5·92	3,789	2·5	14·6*	9,344	*2·5 ft. Storage.
Otter...............	10·6	6,784	5·74	3,674	2·80	1,792	2·1	5·7*	3,674	*2·1 ft. Storage.
Big Pine....	133	85,120	72·10	46,144	2·80	1,792	25 8	14	8,960	
Rainy Lake	14600	9,344,000	7913	5,064,320	330·00	211,200	24	1650	105,600	
Foot Print..........	383	245,120	207·80	132,992	3·11	1,990	66·8	15·5	9,920	
Despair	250	160,000	135·50	86,720	4·98	3,187	27.2	24·9	15,936	
Clearwater.........	175	112,000	95	60,800	6·23	3,987	15·2	31·1	19,904	
Pipestone.....	114	72,960	61·8	39,552	16·81	10,758	3 7	84	53,760	*4·2 ft. Storage.
Manitou....	397	254,080	215·2	137,728	51·08†	32,691	4·2	215·2*	137,728	{ Manitou 31·78.
Otukamamoan..	448	286,720	243	155,520	18·68	11,955	13	93·4	59,776	Anthekumming 19·3.
Little Turtle.......	1806	1,155,840	979	626,560	10·60	6,784	92 4	53	33,920	
Martin..	133	85,120	72·1	46,144	5·29	3,386	13·6	26·5	16,960	
Turtle (West)......	1016	650,240	551	352,640	7·47	4,781	73 8	37·4	23,936	
White Otter.......	335	214,400	181·5	116,160	31·12	19,917	5·8	155·6	99,584	
Clearwater...... ..	95	60,800	51·5	32,960	11·80	7,552	4·4	51·5	32,960	
Lac des Milles......	656	4,198,400	355·5	227,520	90·02	57,613	4	355·5*	227,520	*4 ft. Storage.
Namakin	7100	4,544,000	3848	2,462,720	99 58†	63,731	38·7	497 9	318,656	† { Namakin 39·20. Sandy Point 23·30. Kapetogamak 37·05.
Eagle Lake..... ...	933	597,120	505·7	323,648	22·60	11,464	22·3	505·7†	323,648	†22·3 ft. Storage.
Wabigon...........	1013	648,320	549	351,360	49·16†	31,462	11·2	245·8	157,312	† { Wabigon 36·71. Dinorwic 12·45.
Lac Seul....	10422	6,670,080	5649	3,615,360	367·00	234,880	15·4	18·35	11,744	Area drainage basin by Wm. Thibaudeau:
Minnitaki (a).	5102	3,265,280	2765	1,769,600	83·90	53,696	32·9	419·5	268,480	(a) Lower Outlet.
(b).	3417	2,186,880	1852	1,185,280	73·97	47,341	25·1	369·9	236,736	(b) Abrams Falls.
Otter	2416	1,546,240	1308	837,120	14·91	9,542	87·8	74·5	47,680	
Indian............	278	177,920	150·6	96,384	15·85	10,144	9·5	79·2	50,688	
Maneigweiss.......	82	52,480	44·4	28,416	21·72	13,901	2	44·4†	28,416	†2 ft. Storage.

Existing Plants on the Winnipeg River in Manitoba.

Two hydro-electric plants are now in existence on the river in Manitoba, namely, the City of Winnipeg municipal plant, and the Winnipeg Electric Railway Company's plant. These plants have been in commission for some time, the former commencing the delivery of current in the fall of 1911, and the latter at an earlier date.

(*a*) *City of Winnipeg Municipal Plant.*—The municipal plant of the city of Winnipeg is located at Point du Bois, about 75 miles from the city. (See Plates 5 to 7.) The plant consists of a dam along the crest of the Point du Bois falls, made up of about 700 feet of rock fill with top elevation at 214, city of Winnipeg local datum (zero of city of Winnipeg datum equals 769·1 Water-power Survey datum), and two concrete spillway sections with crest at elevation 206·5, and of 600 and 480 feet in length, respectively. A forebay canal with a 1,400-foot part overflow and part retaining concrete wall, on the river side, conveys the water from the dam to the power-house. The latter has been constructed to provide for both present and future needs. Only half the power-house has been completed to date. The apron, stop-log piers, and upstream portions of the pressure chambers of the remainder of the plant have also been built in preparation for future enlargements. The full plant when completed will contain seventeen bays and will have a capacity of 88,000 water-wheel horse-power at full gate. The present installation consists of five units, each of 5,200 horse-power turbines at full gate, which at 45 feet head pass 1,250 cubic feet of water per second at maximum output; they run at 164 revolutions per minute. The increase in the demand for power is raising the question of installing additional units, and it is understood that two will be placed in position during the coming season. The current is transmitted 77 miles over the city's transmission line to the city, where it is used for lighting and general distribution.

(*b*) *Winnipeg Electric Railway Plant.*—The plant of the Winnipeg Electric Railway Company is placed on what is known as the Pinawa channel of the Winnipeg river about 11 miles below its mouth. (See Plates 8 to 10.) The Pinawa channel is the back channel of the Winnipeg river and separates from it just below Otter falls. A rock fill, concrete capped diversion weir has been built across the main channel of the river, by means of which a large proportion of the flow is diverted down the Pinawa to the company's plant. This flow varies from 5,000 to 11,000 second feet, depending on the stage of the river. The company hopes to ultimately carry 12,000 second feet to the plant by this channel. This can only be accomplished by one of two ways: by a further enlargement of and straightening of the channel or by raising the diversion weir across the main channel; either method will involve a heavy expenditure.

The Pinawa channel itself has been greatly enlarged and improved by excavation. A head of about 39 feet is normally developed at the plant, and there are installed at present four 2,000 k.w. and five 1,000 k.w. generators, making a total of 13,000 k.w.; these machines can be, and often are, run at a 50 per cent overload, making in all an output of 19,500, or say 26,000 water-wheel horse-power. The current is transmitted to Winnipeg, 52 miles distant, and used for operating the street railway and for general sale and distribution.

Undeveloped Power and Storage of the Winnipeg River in Manitoba.

Following is a short summary of the undeveloped powers of the Winnipeg river, in so far as the present studies of the same can permit of their final discussion. A complete profile of the river from lake Winnipeg to the Lake of the Woods has been run by the power party, and all existing and proposed developments have been tied in to the same datum, i.e., the mean sea-level. (Plate 11.)

The proposed head and tail-water elevations of the developments referred to herein must not be considered as final. This report is too brief to permit the detail of

the head-and tail-waters of the various plants to be fully discussed, also in some cases certain essential information is not yet to hand; the elevations which are given will, however, be followed fairly closely in the final report.

The power capacity of the different sites is given in terms of the power on the turbine shaft, the purpose being to reduce all to a common basis of comparison. As power may, in the future, be developed for direct use on the ground as well as for transformation into electrical energy, either for local use or for distribution in a distant market, this basis of comparison of the different sites is deemed fair to all. This system has been followed on the plan (Plate 12) published herewith, both in respect to the prospective and the existing plants; attention is called to the explanatory note on the plan.

(*a*) *Slave Falls.*—About one mile below the present plant of the city of Winnipeg, at Point du Bois, are what are known as the Eight Foot falls, which, as is indicated by their name, have a drop of about eight feet; this drop is concentrated and takes place over a well-defined ridge of rock between high rocky banks. The city of Winnipeg have endeavoured to add to their head, and to lessen their tail-water ice troubles, by blasting away a portion of this ridge. But little reduction has been made, however, on the total drop available at this point.

Below these falls the river broadens out, flowing between high rocky banks with but little current. About 3¾ miles below Eight Foot falls, the Slave falls, with a drop of some 17 feet, occur. The natural method of developing the two falls is by a dam and power station at Slave falls, raising the head-waters sufficiently high to drown out Eight Foot falls, i. e., to the tail-water elevation of the city plant. Such a development at this point would concentrate a head of about 26 feet. Care being taken in the design and layout to prevent any interference with the existing city plant, the head and tail-water elevations will be 928 and 902, respectively, under normal conditions.

The field work of the Power Survey party over this section has been completed, and while the final plans and designs are not yet completed, they are sufficiently advanced to show that a most economical development of the site can be obtained. On account of the short length of the dam and the necessity for protecting the interests of the city plant above, reliance must be placed on sluice control, although sufficient spillway discharging capacity to take care of any sudden rises in the river will be provided.

The contours of the rock surface at Slave falls lend themselves admirably to the layout of a plant capable of completely developing the full power of the site. Plans and estimates are being prepared, and are based on a preliminary installation utilizing the minimum flow of 12,000 second feet, and of being readily extended to accommodate 20,000 second feet. The full development of 25,000 second feet (which depends on a practically total regulation of the whole upper basin) can be economically secured by further additions to the power-house. The power which will be available under these three conditions, on a continuous 24 hour, 80 per cent efficiency basis, will be 28,400, 47,400 and 59,000 horse-power respectively.

(*b*). *The Seven Sisters' Falls.*—Between this Slave Falls plant and the diversion weir of the Winnipeg Electric Railway, across the main river at the entrance to the Pinawa channel, there is the small drop at Sturgeon Falls, which at high water is almost eliminated.

The power party have not as yet started on the survey of the main river channel below this weir, and it is impossible at present to reach any conclusions with respect to the development of the drop thereon, amounting to some 70 feet. The aim which will be kept in view in development will be to maintain the head-water above the weir at a sufficient elevation to divert down the Pinawa channel the amount of water to which the Winnipeg Electric Railway Company are entitled. This head-water elevation will be carried down stream as far as the contours of the banks will permit, and the reach

will be developed, so far as possible, along the lines outlined above, i. e., the tail-waters of one plant being the head-water of the next. It is recognized that until some regulation takes place in the upper waters, there will be insufficient water for profitable development in the main channel, as the street railway plant at present utilizes the greater portion of the minimum flow.

Pending the completion of the field work along this reach it has been assumed that 40 feet of the available head of 70 feet can be economically developed; this is a conservative estimate, used to obtain a fair tabulation of the total power available on the river in Manitoba.

(c) Lac du Bonnet Storage.—While the survey of Lac du Bonnet is not as yet completed, sufficient information has been obtained to indicate to what extent it can be utilized as a storage basin, particularly in conjunction with the development of the McArthur falls immediately below. The present limiting factor in any raising of the level of Lac du Bonnet, appears to be a big open muskeg located to the west of, and about 1¾ miles distant from the lake. This muskeg varies in width from 1 to 3 miles and is understood to extend to lake Winnipeg, where it is drained by Catfish creek. The land rises slowly from the western end of the lake to the elevation of this muskeg, which is roughly 828·8. An embankment about one mile in length would be necessary to permit the lake level being raised above this elevation, and the effect of such raising of the lake level on the drainage of the district is uncertain at this stage. For this reason the muskeg is at present taken as the upper limit of the Lac du Bonnet level.

The following elevations in this connection are important:—

Elevation of muskeg to the westward.	828·8
Maximum high-water level of Lac du Bonnet.	826·4
Usual summer level of Lac du Bonnet.	819·3
Low-water level of Lac du Bonnet.	818·0
Proposed spillway level to control this reach	825·0

Lac du Bonnet has an area of 32·7 square miles, and the utility of a storage of this capacity for peak loads, on any development immediately below, is at once obvious; one foot of storage on the lake means 20,900 acre feet, and will supply a continuous flow of 10,560 second feet for 24 hours, or 25,350 second feet for 10 hours.

The area of the lake is especially important, for the development of the McArthur falls is essentially one of low head, and it is hence desirable to take full advantage of peak load storage without at the same time interfering greatly with the head.

(d) McArthur Falls.—The river leaves the lake at the western end by way of the first McArthur falls. Several islands break up the river at this point, and there is a fall of approximately 6½ feet taking place in three channels. The second McArthur falls occur about one mile down-stream from the first, and have also a drop of about six feet. The two McArthur falls can be obviously best combined at the lower, and in order to secure a head which is economical of development it is necessary to raise the level of Lac du Bonnet to the highest permissible limit, the tail-waters being fixed by the head-waters of the du Bonnet falls.

As the head to be developed here is low it is desirable to maintain the surface of Lac du Bonnet at as high an elevation as is possible at all seasons of the year. To this end a very complete sluice control is contemplated in the proposed dam by means of which the lake can be maintained at elevation 827 at all seasons. The layout which has been studied in connection with this plant provides, in addition to the contemplated sluice capacity, an overflow section of 1,500 feet in length, with crest at elevation 827. In addition to this 1,500 feet of spillway, the site possesses great natural advantages for the lengthening of the same, should it be considered advantageous to

do so. The large island which here divides the river into two parts, rises but little above elevation 825, and an additional 1,500 feet of spillway, making in all 3,000 feet, could be inexpensively provided. With the above provisions for discharge, there will be no difficulty in dealing with the largest floods which may occur.

The head-waters of the du Bonnet combination below will probably hold the tail-waters of the McArthur plant at elevation 807, so that a head of from 18 to 20 feet can be counted on at this site under normal conditions. The proposed location of the power-house is on the west side of the river, the contours being very favourable. Very little land will be flooded, as the banks rise fairly abruptly from the waters edge. Certain hay lands at the eastern end of Lac du Bonnet will be submerged, but their value is unimportant in comparison with the benefits of the power to the district at large.

The site will produce 21,800, 36,300 and 45,400 horse-power on the basis of 12,000, 20,000 and 25,000 second feet discharge.

(*e*) *The du Bonnet Falls.*—The Grand du Bonnet falls, about 3¾ miles farther down stream, are formed by a group of four drops totalling in all 34 feet, and taking place in a length of three-fourths of a mile; half a mile farther down comes the Little du Bonnet falls with a drop of 9 feet.

The possibility of combining the du Bonnet and the McArthur groups into one development was carefully investigated, but the unfavourable surface elevations and conditions on the west bank would not permit of this. Embankments varying in height from 10 to 30 feet, with a total length of about seven miles, would be necessary for a complete combination which would leave no unutilized drop at the McArthur falls.

This being the case, the separate development of the du Bonnet and the McArthur groups was determined on as forming two developments, each economic in itself, and at the same time taking full advantage of every foot of drop in the river.

In determining the head which is available here, the question of the disposal of Whitemud falls, three miles farther down the river must be taken into consideration. Proposals have been submitted to the department having in view the complete blasting away of the rock ridge over which the drop at that point occurs, lowering the tail-water of the du Bonnet group, and thus adding some 12 feet to the head of the same. While it may be economically feasible to carry out this scheme in part, the possible necessity for maintaining a navigable current past the Whitemud falls may prevent the full scheme being realized. Navigation is, however, at present a long distance in the future and at least a partial blasting may be feasible. A full study of this problem will be completed this season, and navigation interests will be carefully protected in whatever solution is reached.

In the meantime the tail-water of the du Bonnet falls is taken at 757 and the head-waters at 805, giving an available head of 48 feet.

The layout proposed places the power-house on the right bank of the river below the Little du Bonnet falls. The power-house connects with the high land on the right bank by means of a core wall embankment and an ice sluiceway section. From the river end of the plant, a concrete dam, containing 15 sluices adjoining the power-house, extends across the river and connects with the high land on the left bank, by means of a core wall embankment section. The contours and general features of the vicinity fit in well with this layout, and very little flooding will take place. With a 48-foot head and under the same conditions set out above, this site will develop 52,000, 87,000 and 109,000 water-wheel horse-power.

(*f*) *Whitemud Silver and Pine Falls.*—Three and one half miles below the Whitemud falls referred to above, are the Silver falls, with a drop of 22 feet. Four and one half miles farther down come the Maskwa rapids and Pine falls, with a total drop of about six feet, bringing the river down to lake Winnipeg level.

The concentration of the greatest permissible drop at the Pine falls has been the governing idea in this proposed development. The bank contours above Pine falls are not very favourable to a complete flooding out of Whitemud falls, i.e., of raising the head-waters to elevation 762. Elevation 755 could be attained without difficulty, however. Until the best method of disposing of Whitemud falls is ascertained, the exact elevation of the future head-waters of Pine falls cannot be determined; for present purposes, however, it can be taken as 755. The tail-water will vary with the elevation of lake Winnipeg: assuming it will average 712, it will leave a net head of 43 feet.

The layout under consideration consists of a solid concrete spillway section 950 feet long, crossing the river from the high land on the north bank, and connecting with the power-house on the south bank at the lower end of the existing disused power canal. The plant will develop, under the conditions set out above, 47,000, 78,200 and 98,000 water-wheel horse-power.

A table of the powers of Winnipeg river in Manitoba under the different conditions of flow above discussed is here given. In making use of this table, careful attention is called to the foregoing summary remarks in connection with each site, and the table should only be used in connection with the same.

WATER POWERS ON THE WINNIPEG RIVER IN MANITOBA.

Site.	Head.	Unregulated flow of 12,000 second feet minimum.	Regulated flow of 12,000 second feet.	Maximum regulation of 25,000 second feet.
*City of Winnipeg municipal plant.	48′	52,300	87,300	110,000
Slave falls	26′	28,400	47,400	59,000
*Winnipeg Street Railway plant	39′	42,500	42,500	42,500
Seven Sisters (say)	40′	....	29,100	47,400
McArthur	20′	21,800	36,300	45,400
Du Bonnet	48′	52,000	87,000	109,000
Pine	43′	47,000	78,200	98,000
		244,000	407,800	511,300

*Existing power plants here.

CONSTRUCTION WORK PROCEEDING UNDER THE SUPERVISION OF THE WATER-POWER BRANCH.

The Stave Falls Plant.

The plant of the Western Canada Power Company is located at Stave falls on the Stave river, about 5½ miles below the outlet of Stave lake, and 5 miles north of Ruskin, a station on the main line of the Canadian Pacific railway, 30 miles east of Vancouver. The normal elevation of Stave lake is about 205 feet above sea-level, and originally there was a drop of about 15 feet in Stave river between the lake and the power dam. The dam itself is about 55 feet in height, with its present upper limit at elevation 215, although it and the other headworks are designed for a future crest elevation 230, when a future demand for power warrants the utilization of the maximum storage capacity of the lake.

There are now installed two 13,000 horse-power units and an immediate addition of two more similar units is contemplated. The normal working head is now 100 feet, and the plant, when completed, will have an installation of 52,000 horse-power.

A second power site, about 3 miles below the upper and involving practically the same head, will be developed by the same company as soon as the market demands, making available in all about 100,000 horse-power.

Certain questions between the Government and the Western Canada Power Company having arisen, respecting formal approval of the partially completed works at Stave falls, the land required for power site and for flooding purposes and respecting the most advantageous method of utilizing the power resources of the Stave river at the Stave Falls site, and at a second power site at the mouth of the river, it was decided between the Government and the company to secure the opinion of a recognized expert. Accordingly, Mr. J. R. Freeman, consulting engineer, visited the two sites in July, 1911, for the Department of the Interior, to report on the character of the design, the quality of construction of the dams and other structures of the Stave Falls plant as affecting public interests, the height to which flowage rights on Stave lake should be allowed, the conservation of the powers of the river to the greatest possible extent, and the proper development and disposal of the lower site in the interests of the full power development of the river.

After a full investigation on the ground, and a careful study of all the plans, reports, run-off data, etc., which were available, Mr. Freeman reported to the department that the works were designed and being built on generous lines, and that the character of the construction was of the very best. He advised that the company be allowed to raise the level of Stave lake to the highest practicable contour, in order that the full run-off of the basin could be stored and made available for power, and also that the lower site should be developed by the same company which controlled the upper. Such a course would prevent the duplication of transmission lines, and furthermore, a large part of the value of the lower site comes from the control works at the outlet of Stave lake, thus greatest good would be realized by having the two powers developed under single management. Plates 13 to 15 show the plant of the Western Canada Power Company at Stave falls, as constructed.

The Coquitlam Dam.

The construction of the hydraulic fill Coquitlam dam, by the Vancouver Power Company, at the south end of Coquitlam lake, in connection with their power development at Buntzen lake, has been proceeded with during the past year. (*See* Plates 16 to 18.) The services of Mr. J. R. Freeman were continued throughout the year for supervision of the construction of the dam, and the protection of the domestic water supply of the city of New Westminster.

A report by Mr. R. S. Stronach, resident inspecting engineer, of the progress of construction from the commencement of the work is attached. The preliminary clearing of the dam site, the construction of sluice and water supply tunnels and the clearing of the timber from the margins of Coquitlam lake, involved a far greater expenditure of time, labour and money that the actual construction of the dam itself will require. During the past year the work has progressed rapidly and satisfactorily, clearing operations were pushed aggressively, as well as the preliminary work on and around the dam site. Actual sluicing of material into the dam began on October 7 last; up to date (March 31, 1913) 310,000 cubic yards, or 73 per cent of the whole had been deposited, and it is estimated that all the material will have been sluiced into the dam by July 1. The character of the work completed, and under way, is in every respect of the finest, the company has spared no expense to meet the department's requirements with respect to stability of structure and protection to the water supply of New Westminster.

The clearing and general cleaning up around the work will be carried on during the coming season.

Horseshoe Falls Plant.

The Horseshoe Falls plant (see Plates 19 to 22) of the Calgary Power Company on the Bow river, about 43 miles west of Calgary, has been in continuous successful operation throughout the year, and an additional 6,000 horse-power unit is now being installed. The rapid growth of the power market, combined with the low run-off conditions on the Bow river during the winter season, has forced the company to take most aggressive action in providing storage and additional power capacity.

Minnewanka Dam.

The surveys of the Bow River basin in the season of 1911-12, by the engineers of the Water-power Branch showed the great natural advantages for storage at lake Minnewanka. The Calgary Power Company, as stated above, required additional power from some source at the earliest possible date, and the quickest means at their disposal was to increase the low water flow by means of storage at lake Minnewanka. To this end, they entered into an agreement with the department for the construction of a dam at the outlet of lake Minnewanka, and by this means 44,000 acre feet storage has been obtained. Work was started early in March, 1911, and as it was desired that the dam should be completed in time to impound the high flows of June and July, work was rushed in every possible respect and the dam completed in May (Plates 23 to 25) in time to store the high water. Mr. K. H. Smith, an engineer of the Water-power Branch, was appointed inspecting engineer, representing both the Water-power and Dominion Parks Branches of the department. Every possible precaution was taken against the impairment of the scenic beauty of the Canadian National Park, the company cheerfully co-operating with the Dominion Parks Branch and the Water-power Branch in clearing the flowed margin of the lake and generally in giving the dam an environment even more attractive than before.

Kananaskis Falls Power Plant.

The Minnewanka storage, not providing a sufficient addition to their output, the Calgary Power Company has already started the preliminary work on the ground for the development of a power plant (*see* Plates 26 to 28) at Kananaskis falls, about two and one-half miles above its present plant at Horseshoe falls. There is here a head of 70 feet, and as a result of the power surveys of the Water-power Branch in that vicinity, the department has been able to give instant approval to the company's proposal.

Plans of the general layout were submitted by the company on February 25 last, and the general principles of the departmental approval are: The provision for the discharge of at least 40,000 second feet without overtopping the permanent works; a sufficient automatic discharge over the dam to properly protect the Canadian Pacific Railway Company's bridge over the Kananaskis river immediately above the proposed plant; and a stable and safe design of the dam and works. Initial work is now proceeding on the ground, and Mr. K. H. Smith, who has been appointed resident inspecting engineer to properly safeguard the interests of the department, will proceed to the site before the more important work is commenced. A more complete report covering the plant is submitted by Mr. Hendry.

Lake Louise Power Plant.

The Canadian Pacific Railway Company last summer enlarged their existing power plant at the outlet of Lake Louise, for the purpose of securing additional power to light the company's famous chalet at the lake. While acting as resident inspecting engineer at Lake Minnewanka, Mr. K. H. Smith also exercised a general oversight of

this small development. Certain changes with respect to the discharging capacity of the dam were insisted upon by the department, and care was taken to protect the natural scenic beauty of this particular part of the Canadian National Park.

City of Prince Albert Power Plant.

The city of Prince Albert started actual construction on their power plant at La Colle falls in the spring of 1912, under an agreement with the department, dated September 1 last. Mr. E. B. Patterson, C.E., has acted as resident inspecting engineer for the Water-power Branch and his report on the progress of the work is attached. This development is of particular interest because the dam is of the Ambursen type, founded on impervious blue clay, and a navigation lock forms part of the permanent river works. The dam has been designed to allow the passage of 180,000 second feet without overtopping the permanent works, or interfering with existing interests above the site, which, in view of all existing records, is considered an ample allowance. A fair start has been made on the work and rapid progress is anticipated during the coming season. (*See* Plates 29 to 31.)

Proposed Cascade Power Plant.

In the agreement between the department and the Calgary Power Company with respect to the Minnewanka storage dam, the department retained the right to a continuous run-off of 150 second feet past the dam, for power development purposes within the Canadian National Park. It is estimated that this run-off, in conjunction with the reserve storage of the lake over and above that for the power company will warrant the installation of a Government power plant of 1,200 horse-power on the Cascade river below the dam, and all permanent essential intake works were placed in the dam for this purpose, under the supervision of this branch. All surveys for the site have been made under Mr. Hendry's direction, and plans are now in course of preparation for the complete plant, which it is expected will be constructed at an early date for the Dominion Parks Branch under the general direction of this branch. (*See* Report 10.)

SOUTH SASKATCHEWAN WATER SUPPLY DIVERSION PROJECT.

The question of an adequate domestic water supply for the present and future needs of the southern portion of the province of Saskatchewan has been one of vital interest for several years. This section of the province is not supplied with surface and underground waters in sufficient quantity to adequately provide for present needs, much less for the anticipated growth of the country. The question has occupied the earnest attention of the Provincial Government, the cities of Regina and Moosejaw, the surrounding municipalities, the Canadian Pacific Railway Company, the Grand Trunk Pacific Railway Company, and the Canadian Northern Railway Company; the future development of the whole district depends, to a large extent, on obtaining a satisfactory supply from some other than present sources. The unanimous opinion of the engineers who have investigated the question to date is that such source can only be found in the South Saskatchewan river, and the project which has so far been considered and investigated, involves the following essential features:—

(1) The securing of 100,000,000 gallons per day from the South Saskatchewan river from a point about 15 or 20 miles southwest of the Elbow.

(2) The development of sufficient power at the point of diversion either by the construction of a hydro-electric plant, or from some other source, to pump the water to the top of the height of land near the river bank.

(3) The construction of a gravity pipe line about 170 miles long to supply the cities of Moosejaw and Regina, and the surrounding district.

The total cost of the complete scheme has been roughly estimated to lie between $15,000,000 and $20,000,000.

The essential feature in connection with the above scheme was the securing of sufficient power (some 12,000 horse-power) to accomplish the necessary pumping at the point of diversion from the river. The natural source of this power is the South Saskatchewan river, and a hydro-electric installation was the obvious solution. It was in connection with this feature of the scheme that the Water-power Branch became interested in the project and, as power was the basic feature of the whole water supply project, that phase of the question was left with the Water-power Branch to investigate, while the other phases of the question were to be attended to by the Commissioner of Irrigation.

Considerable existing information with respect to the possibilities of water-power development along the reach of the South Saskatchewan river in question was in the possession of this branch, and this was sufficient to indicate the unsatisfactory and unpromising conditions which were to be encountered; before any elaborate field surveys were undertaken it was deemed advisable to have a reconnaissance survey made of this particular portion of the South Saskatchewan river by one of the departmental consulting engineers. Accordingly, Mr. J. B. McRae, who had in his private practice already made a careful study of power possibilities on the same river, visited the site of the proposed dam for the purpose of giving an expert opinion as to the possibilities of a successful and economic hydro-electric development.

In company with Mr. D. L. McLean, Chief Engineer of the Manitoba Hydrographic Survey, Mr. McRae made a reconnaissance examination of the reach of the river under consideration, early in October last, and reported the results of the same to the department. In this report the previous views of the branch were entirely confirmed as to the question of suitable power development. The conclusions in brief were that there was not sufficient water available in times of low water during the winter months to supply the power required for the complete scheme, although the possibility of remedying this by storage was recognized; that, apart from this, the question of a suitable site for an economic development was doubtful; that other sources of power, such as coal, gas, oil, &c., provided economic possibilities; and, as a consequence, it was deemed advisable to have a thorough investigation made into all other available sources of power, and that the services of Mr. H. E. M. Kensit, a hydro-electric engineer of special qualifications in this class of investigation, be secured to prepare an exhaustive report on the comparative costs of the alternative power installations which might be utilized. Mr. McRae further advised that it would be unwise to incur any additional expenditure on water-power investigations along the South Saskatchewan river until Mr. Kensit completed his studies of alternative sources, and that any further water-power surveys should be based on Mr. Kensit's conclusions. On this basis the matter was allowed to rest, while Mr. Kensit proceeded with and completed his studies. For his report and conclusions see Part 12.

INTERNATIONAL JOINT COMMISSION.

The reference before the International Joint Commission respecting the proper elevation of the Lake of the Woods has resulted in an enormous amount of research work by the officers of this branch, and a great deal of field work by the engineers of the Manitoba Hydrographic Survey. The field work undertaken in this connection has involved extensive meterings and field surveys of existing structures at the outlets of the lake of the Woods, and metering of the upper waters or tributaries of Rainy lake; also a diligent research into all existing records of discharge, lake levels, plans, reports, &c., &c., which are pertinent to the question. When the present work is completed, and the results compiled, it is hoped there will be sufficient data to

enable a strong and conclusive statement to be made to the International Joint Commission for the protection of the interests of the important water-powers of the Winnipeg river in the province of Manitoba.

RED AND ASSINIBOINE RIVER SURVEYS.

The survey of the Red river from Winnipeg to the international boundary, undertaken at the request of the Red River and Hudson Bay Navigation Association, and later enlarged to include the Assiniboine river within the limits of Winnipeg at the request of the Winnipeg and St. Boniface Harbour Commission, was commenced early in August last year and was completed the first week in January. The work was placed under the charge of the chief engineer of the Manitoba Hydrographic Survey, and a special staff of engineers was placed in the field. The survey work was carried on and completed with the utmost despatch, and the notes are at present being reduced and plotted in the Winnipeg office. The plans particularly desired by the Harbour Commission covering the Red and the Assiniboine rivers within the city limits have been recently completed in six sheets, and a set has been furnished to the Commission. The full set for the entire survey will be completed at the earliest possible date.

RECLAMATION.

A short résumé of the principal reclamation projects in which this branch has been interested during the past year follows. The various schemes in the Railway Belt of British Columbia have been visited and reported on from time to time by the engineers of the Railway Belt Hydrographic Survey.

Pitt Meadows Reclamation.

The land known as the Pitt Meadows lies about 17 miles eastward from Vancouver to the north of the Fraser river, and extends northward on either side of the Pitt river to the southern shore of Pitt lake (Plate No. 32.) The waters of the north and south fork of the Lillooet river from the east uniting, find their way through the meadows into the Pitt. All the waters bordering on or running through these lands, are subject to the daily tidal fluctuations and are directly affected by the yearly high and low-water conditions of the Fraser river.

The land is traversed by sloughs and old channels, and, with the exception of a few rocky ridges, is low and swampy and is, in its natural condition, quite unfitted for agriculture. Portions of it are, or have been, previous to reclamation, flooded during the fall, winter and summer seasons, and the whole is subject to periodical inundations in times of extreme high water on the Fraser. On the other hand, the land is level, and is not cumbered with the heavy timber and dense underbrush which retard the development of the surrounding higher lands; the soil, composed mainly of river silt and decayed vegetable matter, is very rich, so that the land, when properly ditched and dyked, makes the best of farm land.

Several comprehensive schemes of reclamation, covering large sections of the meadows, have been from time to time considered, some of which have been carried to successful completion. Two of the more important and typical are the Rannie and the Bauthier projects.

The Rannie Project.

Late in the year 1911, Mr. W. A. Rannie, under authority of an Order in Council dated June 2, 1909, commenced work on the reclamation of a large block of the Pitt River meadows east of the Pitt river, and lying between the southern end of Pitt lake and the North Lillooet river, and comprising 7,052·4 acres in townships 40

and 42, E.C.M. The agreement of the department called for the completion of the reclamation by June 2, 1913; the estimated cost of the reclamation works was about $83,000.

The general scheme of drainage is shown on Plate 32, and consists of a dyke leaving the high lands to the northeast, and paralleling the south shore of the Pitt lake and the east bank of the Pitt river, and connecting with a rocky ridge at the southwest corner of the reclaimed land.

A short dyke leaves the last-named ridge and runs parallel to, and north of, the North Lillooet river, crossing the Sturgeon slough, and connecting with the high land to the east. A ditch or drainage canal runs parallel to and along the inner side of the said dykes, and supplied the material for their construction. The Sturgeon and other branch sloughs which traverse the track in various directions form collecting canals which, together with the ditch above referred to, carry the surface and drainage water of the reclaimed lands to the pumping station. This station is placed on what was the old main channel of the Sturgeon slough, and the interior waters are pumped into the Pitt river during such times as they will not flow off by gravity through the flood gates in the dyke. There are in all about eleven miles of dyke, of an average height of about 10 feet, the elevation of the top being placed 2 feet above the high water mark of the great Fraser river flood of 1894.

The reclamation works have been visited and reported on from time to time by the engineers of the Railway Belt Hydrographic Survey, and are now completed. A fianl inspection will be made before the lands can be patented to the applicant.

The Bauthier Reclamation Project.

The land covered by the Bauthier project is situated in townships 9 and 12, E.C.M., to the south of that included in the Rannie scheme. Plate 32 shows the location of the land included in both these schemes.

Work was started by Mr. Augustin Bauthier, under authority from the department dated April 6, 1909, requiring that work be commenced and that he file, within 90 days, complete plans and profiles of the same, and by April 6, 1911, file an engineer's report that the work had been completed and the land reclaimed. The total area to be reclaimed was some 475 acres.

The scheme of reclamation consists of a combination of dyking, ditching and pumping. A dyke extends along the north boundary of the property from the river to the high ground, a distance in all of nearly two miles. This dyke is of good construction, averaging from 6 to 8 feet in height above the level of the ground, is from 4 to 8 feet wide at the top and about 35 feet wide at the base. The dyke is keyed down to the clay subsoil by means of a core excavated therein, and the whole is built up of the clay subsoil, the loam being discarded. The top of the dyke is well above the flood level of 1894. This dyke crosses the Sturgeon slough, which runs through the property, and parallels the dyke for some distance. Several pipes, varying from 12 to 24 inches in diameter, have been placed through the dyke along this section. At times of low water these pipes drain the slough into the ditch running outside of and parallel to the dyke, and during high water automatic valves close out the outer waters and pumping is resorted to.

The north dyke joins the river, running parallel to the river dyke, and at a sufficient distance inland to protect it from possible erosion of the banks; these dykes are of similar construction. The ditch in this case is on the inner side of the dyke, and collects and carries the drainage to the northeast corner of the property, where a pump is installed to discharge it into the Lillooet river.

The river dyke connects with the dyke along the south boundary of the property, and runs eastward until reaching the wagon road on the east boundary of section 31, township 12, and then turns to the south, paralleling the road until it meets the high

land. The ditch is here placed on the south side of the dyke, and drains into the Lillooet river.

The engineers of the Railway Belt Hydrographic Survey have from time to time visited the works, and have reported on its progress. A final inspection and report was made by Mr. P. A. Carson, chief engineer of the above survey, on August 10, 1911, in which he stated that the departmental requirements had been satisfactorily carried out and that the land had been successfully reclaimed.

Sumas Dyking Project.

A project for the reclamation of the lands surrounding and forming the bed of the Sumas lake, in what has been called the Chilliwack-Sumas drainage and dyking district, has been before the department in various forms since 1876. The interest of the department in the scheme lies in the fact that a considerable portion of the lands to be benefited, including the bed of Sumas lake, are Dominion lands. The scheme has been investigated and reported on by numerous engineers, and different parties and companies have at various times undertaken to carry it to a successful issue. Mainly due to the magnitude of the project, these undertakings have never passed the investigation stage, though most valuable reports, data and material pertinent to the scheme have been forthcoming, and for many years the best advice of prominent engineers has declared that the reclamation project is practicable from both engineering and economic points of view.

The district affected is situated on the south bank of the Fraser river, about 50 miles above its mouth, and 40 miles east of Vancouver. The Dominion lands in and around Sumas lake (comprising some 10,000 or 11,000 acres) are at present useless, and unsuited for settlement, as nearly 9,000 acres in the bed of Sumas lake are perpetually submerged, about 2,000 acres (above low-water level) periodically flooded for several months each summer, during the high-water season of the Fraser and Chilliwack rivers. In addition to the said Dominion lands, there are some 20,000 acres of contiguous lands, which are also subject to regular or occasional flooding from the same causes.

The conditions in the district in question, as well as the proposed method of reclamation, can best be noted on Plate 33. Sumas lake, a shallow body of water with surface at an average elevation of 79, Sumas datum, occupies about 9,000 acres in the centre of a low-lying level, alluvial plain. This lake receives the flow of the Sumas and the Chilliwack rivers, as well as of the lands in the immediate vicinity, and discharges the same, in times of normal water, into the Fraser river. In times of maximum flood, the waters of the Fraser back up over the whole district.

The method of reclaiming the lands, as set out by the engineering board appointed by the Sumas Dyking Commissioners, in a report to the latter dated July 15, 1909, is in brief as follows:

> 'By dyking out the Fraser river; by conducting the Chilliwack river by gravity to the Fraser through a new channel; by conducting the Sumas river to the Fraser between low dykes for the most of the year, providing gates at the outlet into the Fraser, and pumping its waters during extreme Fraser floods, and by pumping interior drainage that cannot be drained by gravity flow.'

In an average year, the level of the Fraser river varies from elevation 71 to 88 (Sumas datum). During the past fifty years the maximum rise of the flood waters occurred in June, 1894, and reached to about elevation 102 feet. The reclamation of all the land below this flood line is the object aimed at. In more detail the general method of reclamation is as follows:—

(1.) To dyke out the Fraser river by a dyke built to elevation 105, limiting the high dyke to the shortest practical length. This dyke may be raised to a

higher elevation in the future if desirable. Its general location will be parallel to and about 1,000 feet inland from the Fraser river.

(2.) To divert the water of the Chilliwack river, preferably through the Luck-a-kuck channel (i.e., the original channel of the Chilliwack) to the Fraser, or if this route for any local reason is found impracticable, then the stream to be diverted from a point on the Vedder channel, to the Fraser via Wilson's slough through what will be known as the New Vedder channel.

(3.) To dyke off the Sumas river from the lake and lowlands adjoining by low dykes built to about elevation 90.

(4.) To provide intercepting canals entering the Sumas at about elevation 86, and thereby cutting off all but thirty-two square miles of drainage area from the Sumas lake bed; constructing also intermediate intercepting canals which shall enter the Sumas at about elevation 73 and which will reduce the lake drainage to about 14 square miles for a portion of the year; constructing drainage canals in the bed of the Sumas lake, draining the 14 square miles of the same thereby, and delivering the water therefrom to the pumps at about elevation 60. During such portion of the year as the intermediate intercepting canal may not be able to discharge its waters by gravity they will be delivered to the pump at as high an elevation as possible in order to reduce the amount of power used for pumping.

(5.) To construct gates across the mouth of the Sumas river to keep out the Fraser at times when its surface is above elevation 86 or 87, and to pump the flow of the Sumas river during such periods.

(6.) To build a pumping station on the Sumas river from which the Sumas waters and the waters draining into the lake may be disposed of.

(7.) To instal a centrifugal pumping plant of a design and capacity suitable for the immediate control of the Sumas river and lake drainage, making provision for the future enlargement of the same.

The estimated cost of the whole scheme as outlined above is in the neighbourhood of one million dollars, and the operating expenses after completion of the work, thirty thousand dollars per year.

Great care has been taken in the preparation of the plans and the best of expert opinion has been obtained from time to time with respect to both the engineering and the economic questions involved. The construction proposed will permit of future additions and improvements should the same be found from experience to be desirable.

The Sumas Dyking Commissioners elected, under authority of an Act passed by the Legislature of British Columbia on April 8, 1905, respecting the Sumas Developing Company, Limited, are at present under an agreement dated February 8, 1913, with the department, to carry out and complete the reclamation of the tract by February 8, 1917. The department has assumed no responsibility as to the design or construction of the reclamation works, but no patent for the Dominion lands will issue until a departmental engineer reports that the lands have been successfully reclaimed, and that the reclamation works have successfully withstood the high waters of the summer following their completion.

The engineers of the Railway Belt Hydrographic Survey will report regularly on the progress of the construction of the works in question.

Columbia Valley Reclamation.

For many years the possibility of reclaiming the bottom lands of the Columbia valley, south of the town of Golden, in British Columbia, has received serious attention. These bottom lands consist of a low flat strip averaging a mile in width and extending from lake Windermere to a point near Donald. During high water these bottom lands are to a large extent covered by the waters of the Columbia river. In

low-water season the river meanders through the flats by many and devious channels, and during extreme low water almost the entire flat is dry, the submerged areas being confined to the main river channel and to a few sloughs and small ponds.

The land forms a strip averaging one mile in width and 33½ miles in length, giving a total of 21,440 acres; a considerable amount of this has, however, been alienated from Government control, and some is occupied by the channels of the river. Allowing for this, there are probably from 12,000 to 13,000 acres of the available land within the Railway Belt, south of Golden, which might be reclaimed.

The bottom lands are alluvial and consist of very fine sand, which, according to men of experience in the Columbia valley, will make first-class arable land.

The method of reclamation offering the best promise of success is a combination of dyking, drainage and pumping. The scheme in brief will be to confine the river to a defined straight course by dykes of sufficient height and stability, and by means of systematic drainage to convey the interior water to pumping stations from which it will be discharged into the river.

No actual construction work has been commenced, although the project has been under consideration for several years. The scheme has been reported on by Mr. Carson, as well as by other Government engineers, and all reports favour the reclamation of the lands in a comprehensive manner.

Pasquia Reclamation Investigations.

The question of the reclaiming by drainage, of the vast stretches of country along the lower Saskatchewan river, was reported on during the season 1911, by the late Wm. Ogilvie, D.L.S., and the conclusions reached by him were so far-reaching, and of such vast import to the district in question, that it was considered advisable to carry the investigations further, and to a conclusion.

For this purpose the services of Mr. T. H. Dunn, C.E., an engineer of extensive experience in reclamation work both in Ontario and California, were secured. Instructions were issued to him on July 2, 1912, setting out the scope that it was desired the investigations should cover.

The 'Pasquia Reclamation Project,' as it is named, covers the low-lying lands on either side of the Saskatchewan river below The Pas. This river, for a distance of 120 miles above The Pas and 70 miles down to Cedar lake, flows through a flat, low-lying, alluvial country, between low banks, which, as is common in alluvial rivers, are often at a higher elevation than the land to the rear. In consequence, a large proportion of the whole district is perpetually swampy, while great stretches are subject to extensive flooding during high water. Any scheme which would tend to drain this district would directly benefit an enormous area of country. The only apparent possibility of securing drainage of even a portion of the area, is by lowering Cedar lake.

A start was made from The Pas by Mr. Dunn, Mr. Charlton, assistant engineer, and a party of six men, on August 3, 1912. From this date until September 23, the party were engaged in a careful reconnaissance of the country affected, and in the examinations of the possibility of lowering Cedar lake.

The conclusions reached by Mr. Dunn are, in brief, that it is possible to lower Cedar lake by possibly eleven or twelve feet, that such lowering would reclaim immediately about 400,000 acres, and ultimately 2,000,000 acres, and that the navigability of the river should be greatly improved.

The question as to the cost of the proposed drainage canal between Cedar and Cross lakes, together with the dredging and improvements necessary along the river, was one which could not be covered in the time, and with the means at Mr. Dunn's disposal. Sufficient information was obtained, however, to convince him that the scheme would be an economic success, and to recommend that the investigation of the project during the succeeding season be prosecuted, in order to secure definite information as to the cost involved.

This recommendation has been approved and steps are being taken to complete the field work during this coming season.

For Mr. Dunn's full report covering his season's work see Part No. 11.

The entire field work during the past season has been carried on with the utmost vigour, and the hearty co-operation of the field staff with the head office organization, has resulted in a high measure of efficiency being attained in the general administration of the branch.

The scope of the work has enlarged even more rapidly than was contemplated, with the result that the staff have been called upon to make extraordinary efforts to keep pace with the same. This rapid expansion which has taken place in the past is called to your attention, as its prospective continuance requires constant forethought and preparation in order that it may be coped with.

I have the honour to be, Sir,
Your obedient servant,

J. T. JOHNSTON,
Hydraulic Engineer.

No. 5.

REPORT OF P. A. CARSON.

KAMLOOPS, B.C., March 31, 1913.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water-power Branch,
Ottawa.

SIR,—I have the honour to submit a report of the work of the Raliway Belt Hydrographic Survey for the year ending March 31, 1913.

This survey has been carried on during the past year under the direct charge of the undersigned, and much exceedingly valuable information has been gathered; the staff has consisted of Messrs. C. G. Cline, B.A.Sc., D.L.S., E. M. Dann, D.L.S., H. J. E. Keys, B.A., and C. E. Richardson, B.A.Sc., assistant engineers, and Miss Allan, stenographer. During June, July and August, Messrs. B. Corbould and H. C. Hughes were engaged as temporary assistant engineers.

I have generally superintended the work and have been engaged on the compilation of a comprehensive report to be published shortly; this, it is hoped, will be of interest and considerable value to all water users in the Railway Belt.

During December and January I was in Ottawa whither I was called in connection with the amendments to the Railway Belt Water Act of 1912.

The systematic investigation of the water resources of the Railway Belt which was initiated in April, 1911, has been carried on during the past year along the lines originally laid down.

It has been found convenient to divide the territory covered into districts, placing one assistant engineer in charge of each. These districts (*see* Plate 1) are as follows:—

(1.) Lower Fraser River Drainage or Coast district.
(2.) Thompson River Drainage or Dry Belt.
(3.) Shuswap Lake Drainage.
(4.) Columbia River Drainage.

I. The first, or Coast district, is in charge of Mr. C. G. Cline, B.A.Sc., D.L.S., and includes all the drainage of the lower Fraser river and its tributaries, large and small, except the Thompson; there are also certain other streams included in this district which drain into Burrard inlet and other arms of the Strait of Georgia.

This district is one in which the precipitation is extremely large, and no irrigation is practiced; the hydrographic investigations deal with the supply of water for industrial water-powers, and in connection with domestic and municipal water supply, drainage, flood prevention, and sewage disposal, the last aspect being of particular importance for the growing cities of the Burrard peninsula.

District No. 1.

REGULAR AND MISCELLANEOUS STATIONS.

Station.	Number.	Sheet.	Township.	Range.	Meridian.
Anderson river (abandoned)	130	Lytton	10	26	W. 6th
Belknap creek	106	Port Moody	7	7	W. 7th
Boulder creek	126	Yale	3	27	W. 6th
Brandt creek	107	Port Moody	7	7	W. 7th
Chehalis river	117	Yale	4	30	W. 6th
Chilliwack river	110	Yale and Port Moody	23	....	E.C.M.
Coquihalla river	119	Yale	5	26	W. 6th
Coquitlam river	123	Port Moody	6	6	W. 7th
Fraser river at Lytton	102	Lytton	15	27	W. 6th
" Hope	101	Yale	5	26	W. 6th
Gilley creek	112	Port Moody	40	....	E.C.M.
Gold creek	122	"	39	....	W.C.M.
Hixon creek	105	"	6	7	W. 7th
Jones lake	125	Yale	3	27	W. 6th
Lillooet river, South	132	Port Moody	12	....	E.C.M.
" North	133	"	12	....	E.C.M.
Mesliloet river, at mouth	103	"	6	7	W. 7th
" upper station	104	"	7	7	W. 7th
Nahatlach river, below lakes	127	Lytton	12	27	W. 6th
" lower station	128	"	12	26	W. 6th
Nikaia creek	134	"	14	27	W. 6th
Norton creek	108	Port Moody	7	7	W. 7th
Pollard creek	116	"	40	....	E.C.M.
Rainbow creek	114	"	6	4	W. 7th
Rushton creek	115	"	5	4	W. 7th
Silver Hope creek (left branch)	120	Yale	5	26	W. 6th
" (right branch)	121	"	5	26	W. 6th
Silver Pitt creek	113	Port Moody	41	....	E.C.M.
Statlu creek	118	Yale	4	30	W. 6th
Stave river	129	Port Moody	4	3	W. 7th
Stein creek	131	Lytton	15	27	W. 6th
Sweltzer creek	111	Yale and Port Moody	22	....	E.C.M.
Viola creek	124	Port Moody	5	6	W. 7th
Young creek	109	"	7	7	W. 7th

II. The Dry Belt was attended to by Messrs. E. M. Dann, D.L.S., and H. J. E. Keys, B.A., assisted by Mr. Corbould as temporary assistant during June, July and August. This district consists in general of that portion of the Thompson river and its many tributaries from Lytton to Kamloops which are within the Railway Belt.

As its name would indicate, the main importance of hydrographic surveys in this district is in the interests of irrigation, and the thorough survey of all water resources which was inaugurated last year was continued and extended, some 69 streams were systematically studied and, on 30 more, miscellaneous measurements were made. Stock was taken of the requirements and suitable supplies for domestic and municipal water-supply. Possible power streams were also investigated.

The investigation of old water records was continued, and existing irrigation works, namely, storage dams, canals, ditches, etc., and possible storage sites have been reconnoitred.

In general, it may be stated that the run-off during 1912 was normal almost throughout this district, whereas 1911 was a very dry season. During the summer of 1912 there were some very heavy rains during the growing season which substantially reduced the water necessary for irrigation.

District No. 2.

REGULAR AND MISCELLANEOUS GAUGING STATIONS.

Station.	Number.	Sheet.	Tp.	Rge.	Mer.
Alkali creek	226	Kamloops	19	19	W. 6th.
Barnes creek	245	〃	20	24	〃 6th.
Blue Earth creek	262	〃	19	26	〃 6th.
Bonaparte river	215	〃	21	24	〃 6th.
Botanie creek	205	Lytton	15	26	〃 6th.
Cache creek	220	Kamloops	21	24	〃 6th.
Cahilty creek	244	Sicamous	23	15	〃 6th.
Campbell creek at Todds corners	250	Kamloops	19	16	〃 6th.
〃 〃 above Campbell Este. division	251	〃	19	16	〃 6th.
Chartrand creek	259	〃	17	21	〃 6th.
Chase creek	260	Sicamous	21	13	〃 6th.
Cherry creek	225	Kamloops	19	19	〃 6th.
Colley creek	271	〃	19	26	〃 6th.
Cornwall creek	209	〃	20	25	〃 6th.
Criss creek	224	〃	22	22	〃 6th.
Daisy creek	229	〃	20	19	〃 6th.
Deadman river above Walhachin flume intake	221	〃	22	22	〃 6th.
〃 〃 in Walhachin flume	222	〃	21	22	〃 6th.
〃 〃 below flume intake, abandoned 1912	223	〃	21	22	〃 6th.
Duffy creek	228	〃	20	20	〃 6th.
Edwards creek, upper station, abandoned 1912	240	〃	22	16	〃 6th.
〃 〃 at Dwicks upper ranch	241	〃	22	16	〃 6th.
Gordon creek	266	〃	21	17	〃 6th.
Greenstone creek	261	〃	17	20	〃 6th.
Guichon creek, above Mamit lake	214	〃	17	21	〃 6th.
〃 〃 at mouth	213	Lytton	Outside	Railway	Belt.
Hat creek at Colleys ranch	216	Kamloops	19	26	W. 6th.
〃 〃 in Hammonds ditch	217	〃	19	26	〃 6th.
〃 〃 at Hat creek ranch	218	〃	22	25	〃 6th.
〃 〃 〃 〃 ranch, lower station abandoned 1911	269	〃	22	25	〃 6th.
Hefferly creek, at mouth	236	〃	22	17	〃 6th.
〃 〃 upper station	237	〃	22	16	〃 6th.
〃 〃 in Anderson ditch	238	〃	22	16	〃 6th.
〃 〃 in Crawshays ditch	239	〃	22	16	〃 6th.
Jacko creek	231	〃	19	18	〃 6th.
Jamieson creek, above B.C. Fruit-lands div	232	〃	22	17	〃 6th.
Jamieson creek, below B.C. Fruit-lands div	233	〃	22	17	〃 6th.
King creek	272	〃	19	26	〃 6th.
Lane creek	267	〃	22	17	〃 6th.
Lloyd creek	273	Sicamous	20	15	W. 6th.
Louis creek	243	〃	23	15	〃 6th.
Maiden creek	265	Kamloops	23	26	〃 6th.
Martin creek abandoned 1911	256	Sicamous	20	13	〃 6th.
Meadow creek	257	Kamloops	17	21	〃 6th.
Monte creek, above Bostock diversion	252	Sicamous	19	15	〃 6th.
〃 〃 below Summit Lake diversion	253	〃	18	14	〃 6th.
〃 〃 Summit Lake diversion	254	〃	18	14	〃 6th.
Moulton creek	247	〃	20	14	〃 6th.
Murray creek	263	Kamloops	17	25	〃 6th.
Neds creek	255	Sicamous	19	14	〃 6th.
Nelson creek	246	Kamloops	20	24	〃 6th.
Nicola river, near mouth	210	〃	17	25	〃 6th.
〃 〃 at Merritt	211	Lytton	Outside	Railway	Belt.
Niskonlith creek	249	Sicamous	21	13	W. 6th.
Oregon Jack creek	208	Kamloops	19	25	〃 6th.
Paul creek, above Pinatan lake abandoned 1912	234	Sicamous	20	15	〃 6th.
〃 below Pinatan lake	268	〃	20	15	〃 6th.
〃 below Paul lake	235	Kamloops	Kamloops	I.R.	

REGULAR AND MISCELLANEOUS GAUGING STATIONS—*Continued.*

Station.	Number.	Sheet.	Tp.	Rge.	Mer.
Pemberton creek	248	Sicamous.	20	14	W. 6th.
Pendleton creek	227	Kamloops	19	19	" 6th.
Peterson creek	274	"	20	17	" 6th.
Quenville creek	270	"	17	21	" 6th.
Robbins creek	264	Sicamous.	19	15	" 6th.
Scottie creek	219	Kamloops	23	25	" 6th.
Spius creek	212	Lytton	13	23	" 6th.
Sullivan creek	242	Kamloops	23	16	" 6th.
Thompson river, S. Thomson at Chase	201	Sicamous.	21	13	" 6th.
Thompson river, N. Thompson at Cooney's ranch	203	Kamloops	22	17	" 6th.
Thompson River, at Kamloops	202	"	20	17	" 6th.
" " at Spences bridge	204	"	17	25	" 6th.
Tranquille river	230	"	20	19	" 6th.
Twaal creek, abandoned 1911	206	"	17	25	" 6th.
Venables creek	207	"	18	25	" 6th.
Witch creek	258	"	18	21	" 6th.

District No. 3.

Work in this, the Shuswap Lake drainage, was in charge of C. E. Richardson. It extends from the Dry Belt to the summit of the Gold range. Fruit growing and all kinds of mixed farming are carried on around Salmon arm and the northerly part of the Okanagan valley, and the precipitation in the growing season is sufficient to render irrigation unnecessary; in the greater portion of the district there is little agricultural development, the land being rolling and rather hard to clear.

There is an important undeveloped water-power on the Adams river which should have a considerable bearing on the agricultural development of the South Thompson valley, furnishing the necessary power to pump water for the irrigation of the arid valley lands.

About thirteen hydrographic stations have so far been established and it is planned to make a reconnaissance of the streams flowing from the north into Shuswap lake.

REGULAR AND MISCELLANEOUS STATIONS.

Station.	Number.	Sheet.	Tp.	Range.	Meridian.
Adams river	301	Sicamous	23	12	W. 6th.
Bear creek	313	"	22	13	"
Bolean creek	306	"	18	12	"
Canoe creek	310	"	20	9	"
Eagle river	312	"	22	8	"
Essel creek	307	"	17	14	"
Fortune creek	309	"	17	9	"
Ingram creek	308	"	17	13	"
Palmers creek	314	"	20	10	"
Salmon river at Woods ranch	302	"	17	14	"
" Slahaltkan	303	"	18	12	"
" Salmon arm	304	"	19	10	"
Shuswap river	311	"	18	9	"
Warren creek	305	"	18	11	"

District No. 4.

Work in this, the Columbia Drainage district was in charge of C. E. Richardson, assisted during the summer months by H. C. Hughes. The area covered extends from the summit of the Gold range to that of the main Rockies, and includes the Selkirks.

The greater part of the Columbia drainage is outside the Railway Belt and the only portion dealt with is that portion above and below Revelstoke and the Upper Columbia from Beavermouth and Golden to lake Windermere.

Around Revelstoke the climate is humid; the timber is heavy and the land difficult to clear. The main interests in the whole district are those of lumber, although some mining is done. The Upper Columbia valley from Golden to Windermere is arid.

There are some good undeveloped water-powers in the vicinity of Revelstoke, and the town is supplied with power from a plant on the Illecillewaet river.

From Golden to the north boundary of the Railway Belt, timber is practically the only interest. There are a few possible water-powers.

The Kicking Horse river is the only important tributary from the direction of the main Rockies, and is well known to all who have toured the Canadian Rockies over the Canadian Pacific Railway.

About twenty-three river stations have been established in this district and many miscellaneous measurements have been made.

REGULAR AND MISCELLANEOUS STATIONS.

Station.	Number.	Sheet.	Tp.	Range.	Mer.
Akolkolex river	408	Sicamous	22	1	W.6th.
Beard creek	423	Spillimacheen	24	19	W.5th.
Blaeberry river	409	Donald	28	22	W.5th.
Bugaboo creek	419	Spillimacheen	outside	Ry.	Belt.
Canyon creek	423A	Donald	26	22	W.5th.
Cartwright creek	424	Donald	25	20	W.5th.
Columbia river, at Revelstoke	401	Sicamous	23	2	W.6th.
" " at Golden	402	Donald	27	22	W.5th.
" " at Spillimacheen	403	Spillimacheen	outside	Ry.	Belt.
" " at Athalmer	404	Spillimacheen	outside	Ry.	Belt.
Emerald river	414	Donald	28	19	W.5th.
Hogranch creek	425	Spillimacheen	24	15	W.5th.
Horse creek	416	Donald	26	21	W.5th.
Horsethief creek	421	Spillimacheen	outsid	Ry.	Belt.
Illecillewaet river	406	Sicamous	23	2	W.6th.
Incomappleux river	407	Spillimacheen	outside	Ry.	Belt.
Jordan river	405	Sicamous	24	2	W.6th.
Kicking Horse river, at Golden	410	Donald	27	22	W.5th.
" " at Field	411	Donald	28	18	W.5th.
" " at No. 2 Tunnel	412	Donald	28	18	W.5th.
" " at Palliser	426	Donald	26	20	W.5th.
Nelson creek	427	Donald	25	20	W.5th.
No. 2 creek	420	Spillimacheen	outside	Ry.	Belt.
Ottertail river	413	Donald	27	19	W.5th.
Spillimacheen river	418	Spillimacheen	outside	Ry.	Belt.
Toby creek	422	Spillimacheen	outside	Ry.	Belt.
Twenty-eight Mile creek	428	Spillimacheen	24	19	W.5th.
Washout creek	417	Donald	25	21	W.5th.
Yoho river	415	Donald	28	18	W.5th.

I have the honour to be, Sir,
Your obedient servant,

P. A. CARSON,
Chief Engineer.

No. 6.

REPORT OF D. L. McLEAN.

WINNIPEG, MAN., March 31, 1913.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water-power Branch,
Ottawa.

SIR,—I have the honour to submit the following as a report of the work carried on under my supervision during the year ending March 31, 1913.

(a) MANITOBA HYDROGRAPHIC SURVEY.

Organization and Scope of Work.

The hydrographic investigations of southeastern Manitoba which have been carried on in connection with the power and storage possibilities of the Winnipeg River system, were extended at the close of the fiscal year 1911-12 to cover the entire province. Permanent office accommodation was secured at 245 Chambers of Commerce, Princess street, Winnipeg, and a small staff consisting of S. S. Scovil, B.Sc., G. H. Burnham, B.A.Sc., and Alex. Pirie, clerical assistant, was provided to commence the work.

While working under various Canadian consulting engineers, and later as assistant chief engineer on the International Commission, river St. John, under M. H. Ranney, C.E., Mohawk, N.Y., the undersigned became familiar with the hydrographic survey methods used by the United States Geological Survey. Advantage of this was taken in securing for the Manitoba work up-to-date equipment and in using or improving on the United States system. Considerable reconnaissance work had to be done when establishing the stations, but at the end of the year there were twenty-six regular stations at which records were being obtained throughout the year, and some forty-one more at which miscellaneous summer readings had been obtained.

Field Work.

After a reconnaissance has been made of the river on which information is desired, the gauging station is established, and a local resident engaged to observe the height of the water. These observations are recorded in a suitable book supplied by the department, and at the end of each week the reader copies the week's readings on a postal card, forwarding it to the Winnipeg office. The hydrographers make visits at such times as changes in river stage would give different points on the rating curve, and at these visits current-meter measurements of the river flow are obtained. The zero of the gauge is checked from time to time, and at each visit the observer's note-book is examined, and any necessary repairs or additions to the station equipment made. As soon as the hydrographers' field notes are worked out they are forwarded to Winnipeg, where they are checked, filed and used for future compilation of stream flow data.

Winnipeg is strategically located with respect to the Manitoba and international waters work, as all the railway lines from the east and west enter Winnipeg. This is of advantage in laying out routes for the hydrographers, so as to enable them to return to Winnipeg at least once a month and bring all their work up to date. It has the advantage over the district system of giving a very good opportunity of keeping a close check on the field work.

Changes in Staff.

As the work progressed, hydrographic data were required, not only in Manitoba but on the work carried on in the drainage basin of the international waters of the upper Winnipeg river. The Red River survey and the power surveys made considerable change in the personnel of the staff for hydrographic work. In July, S. S. Scovil, B.Sc., was appointed assistant chief engineer. In August, G. H. Burnham was placed in charge of the Red River survey party, while Alex. Pirie, W. G. Worden, G. J. Lamb and R. H. Nelson were appointed hydrographers. Owing to the press of other work, these men were engaged on various surveys on the international waters work as well as on their regular stream gauging. W. J. A. Shadwell acted as office assistant from August to October. M. H. Nelson worked at times as hydrographer's assistant in the field and as general office man at Winnipeg. E. B. Patterson, engineer in charge of water-power survey, and later S. C. O'Grady, B.Sc., B.A., in charge of the same work, took a number of meterings in the Winnipeg River basin and at the Grand Rapids, Saskatchewan river; by this use of field parties, much additional hydrographic data were economically gathered.

The following lists give: 1st., the regular stations; 2nd, miscellaneous metering stations; 3rd, gauges used for river heights for power and other survey:—

REGULAR STATIONS.

Station.	River.	Locality.	Date Established.
1	Winnipeg	Slave falls	Oct. 13, 1912.
3	Pinawa channel	Below control dam	May 11, 1912.
4	Assiniboine	C. P. R. bridge, St. James	May 13, 1912.
5	Red	C. N. R. bridge, Emerson	May 17, 1912.
7	Rat	Otterburne	May 23, 1912.
8	Whitemouth	Whitemouth	May 28, 1912.
9	Brokenhead	Sinnot	May 30, 1912.
11	Winnipeg	Norman traffic bridge	June 5, 1912.
14	Fairford	Fairford	June 27, 1912.
15	Winnipeg	East Br., below Kenora power-house	June 27, 1912.
15 (a)	Winnipeg	East Br., above Kenora power-house	June 27, 1912.
16	Winnipeg	North tunnel Island	June 28, 1912.
17	Assiniboine	Brandon	July 4, 1912.
20	Lake of the Woods	Head Race Mill 'C,' Keewatin	July 17, 1912.
22	Lake of the Woods	Old Head Race, C. P. R. culvert	July 29, 1912.
24	Saskatchewan	Le Pas	Oct. 21, 1912.
26	Kettle river	Kettle Falls, Can. Br	Aug. 8, 1612.
27	Kettle	" " Can.-Am	Aug. 8, 1912.
44	Rainy	International falls	Aug. 5, 1912.
52	Souris	Wawanesa	Oct. 8, 1012.
55	Valley	Valley river	Oct. 25, 1912.
59	Ochre	Ochre river	Oct. 18, 1912.
60	Rainy	Emo	Oct. 2, 1912.
61	Swan	Swan river	Oct. 24, 1912.
63	Assiniboine	Millwood	Oct. 11, 1912.
64	Lake of the Woods	Mill 'A,' Keewatin	Dec. 23, 1912.
65	Manigotagan	Lake Winnipeg	Dec. 21, 1912.

MISCELLANEOUS METERING STATIONS.

2	Winnipeg	Grand du Bonnet	Dec. 6, 1911.
6	Roseau	Dominion City	May, 21, 1912.
10	Pinawa channel	Above control dam	June 2, 1912.
12	Red	Below Emmerson	June 13, 1912.
13	Winnipeg	Minaki	June 15, 1912.
18	White Snell		July 4, 1912.
19	Tye creek		July 9, 1912.
21	War Eagle	Darlington bay	July 29, 1912.
23	Middle lake	" "	July 29, 1912.

MISCELLANEOUS METERING STATIONS—*Continued.*

Station.	River.	Locality.	Date Established.
25	Saskatchewan	Grand Rapids	Aug. 8, 1912.
28	Rainy	Beaudette	Aug. 19, 1912.
29	Pipestone	Cromer	Aug. 24, 1912.
30	Hale bay	Kettle falls	Aug. 10, 1912.
31	Pipestone	Ostokes bay, Rainy lake	Aug. 11, 1912.
32	Seine	Rainy lake	Aug. 14, 1912.
33	Small creek	Seine bay, Rainy lake	Aug. 15, 1912.
34	Bear's pass	Swell bay, Rainy lake	Aug. 16, 1912.
35	Big Canoe	N. E. Bay	Aug. 20, 1912.
36	Little Canoe		Aug. 21, 1912.
37	Manitou	Devil's Cascade lake	Aug. 22, 1912.
38	Ash	Ash bay	Aug. 24, 1912.
39	N. W. bay	N. W. bay	Aug. 26, 1912.
40	White Fish creek	" "	Aug. 27, 1912.
41	Webb lake	Rainy lake	Aug. 29, 1912.
42	Lost creek	N. W. bay, Rainy lake	Aug. 29, 1912.
43	Brownlee's creek	Rainy lake	Aug. 29, 1912.
45	Grassy Narrows creek	" "	Aug. 30, 1912.
46	Warsaw creek	" "	Aug. 31, 1912.
47	Frog creek	" "	Sept. 1, 1912.
48	Cranberry	" "	Sept. 5, 1912.
49	Small creek	" "	Sept. 6, 1912.
50	Big island	" "	Sept. 7, 1912.
51	Cypress	Cypress river	Oct. 9, 1912.
53	Whitemud	Westbourne	Oct. 15, 1912.
54	Little Saskatchewan	Minnedosa	Oct. 12, 1912.
56	Pembina	La Rivière	Oct. 3, 1912.
57	Morris	Morris	Oct. 2, 1912.
58	Seine	Ste. Anne de Chieres	Oct. 4, 1912.
52	La Salle	La Salle	Oct. 1, 1912.
67	Bird	Lac du Bonnet	Oct. 19, 1911.
69	Red	Red Wood bridge	Aug. 21, 1912.

GAUGES.

1a	Winnipeg	Point du Bois	Jan. 1907.
1b	"	Hunt Club landing	May 1912.
1c	"	Foot of Upper Seven Sisters	Aug. 1911.
1e	"	Winnipeg City bridge	" 1911.
1f	"	Foot of 1st McArthur falls	June 1911.
2	"	Head of Gr. du Bonnet falls	July 1911.
2a	"	" Little Bonnet falls	Oct. 1911.
2b	"	" Whitemud falls	July 1911.
2c	"	" Silver falls	" 1911.
2d	"	Foot of Silver falls	" 1911.
2e	"	Head of Pine falls	" 1911.
2f	"	Foot of Pine falls	Sept. 1911.
2h	English	Lac Seul	Aug. 1911.
20	Lake of the Woods	Keewatin Traffic Br. Ont. D.W.P.	Nov. 19, 1898.
20	Winnipeg	Tailrace Mill A. Ont. D.W.P.	" 19, 1898.
20	"	Head Norman dam, Ont. D.W.P.	" 19, 1898.
26	Rainy lake	Below Can. Chan. Kettle river	May 1912.
74	Red	St. Agathe	Nov. 1912.

These are also shown on Plate 2.

Information and stream flow data collected from other sources.

All available data taken previous to the date of establishment of survey were collected, and though the information was scattered and meagre, yet the records will be of value when correlated with the additional data gathered by this survey. For the courtesy extended in this compilation, special thanks are due to the following:—

Messrs. Pratt & Ross, consulting engineers, Winnipeg.
Col. H. N. Ruttan, city engineer, Winnipeg.
Mr. Speakman, city engineer, Brandon.
J. G. Glassco, manager, Winnipeg Municipal Light, Heat, and Power.
W. Z. Earle, district engineer, Public Works Department.
L. Voligny, district engineer, Public Works Department, Prince Albert.
Prof. Chandler, University of Minnesota, Grand Forks, N.D.
W. G. Hoyt, district engineer, U.S. Geological Survey, St. Paul, Minn.
W. G. Chace, consulting engineer, Smith, Kerry and Chace, Toronto, Ont.

Office Work.

As briefly outlined above, the field results are forwarded to the Winnipeg office where they are checked and filed, and from them the flow data are computed. A vertical filing cabinet is used for holding the notes, each station is given a station number and all data are filed accordingly. The post cards from the observers are filed in one set of drawers, the gauge books in another, meter and level notes in another, while in a separate section each meter station has a separate folder for the discharge sheets, gauge sheets, description of station sheets, &c., &c. From the field data, gauge-height-area, gauge-height-mean velocity and gauge-height-discharge curves are plotted. From these curves, rating tables are prepared and used for the computing of the daily, monthly and yearly discharges. Mass curves are also prepared where storage problems occur.

Future Work.

During the coming season it is expected that a number of new stations will be established throughout the province to meet the growing demand for accurate data.

(*b*) WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS.

Previous Work and Organization.

In 1911, a reconnaissance of the Winnipeg river was made by John R. Freeman and J. B. McRae, consulting engineers, accompanied by J. T. Johnston and the undersigned. As a result of this, a staff of engineers, with the undersigned in charge, was organized, equipped and immediately placed in the field. A line of check levels was commenced by Eyre M. Dann, D.L.S., and later continued by A. M. Beale, B.Sc., from lake Winnipeg to Kenora. This year these levels were tied in to the United States Geological bench marks at Warroad which are based on the United States coast and geodetic transcontinental line of levels, using as their datum mean sea-level at New York city. With these levels as a base, detailed surveys were commenced at the Grand du Bonnet falls. Gauging stations were also established. (See Plate 4.)

Field Work During 1912-13.

The detailed surveys were continued from the Grand du Bonnet falls to Pine falls and then up to McArthur falls, after which the party proceeded under Assistant Engineer E. B. Patterson, with A. M. Beale, B.Sc., as first assistant, H. Wilson as junior assistant (from May to November), and P. J. Barry, draughtsman, to carry on similar work from Point du Bois down river. This work included contouring the river banks between power sites and detailed survey at each power site. In July, when the survey work had been carried from Point du Bois to Sturgeon falls, work was suspended, and the party detailed to survey the Grand rapids on the Saskatchewan river. This party returned to the Winnipeg river in October, and taking up the work at the head of the McArthur falls, continued the contour survey work around Lac du

Bonnet up the Bird river and up the Pinawa channel to the City Bridge, then up the main river to Lac du Bonnet, and at the present time this work is being continued up to the Seven Sisters falls to connect with the work completed on the upper portion of the river. In November, E. B. Patterson left the survey to take charge of the inspection work for the Water-power Branch at La Colle falls, Sask.; W. G. Worden was placed in charge and continued to the end of December when, through sickness, he left the survey; S. C. O'Grady was then placed in charge and has carried on the work to date. In January, R. H. Nelson was made assistant to Mr. O'Grady, who is at present assisted by A. E. W. Hanington, B.Sc.

Office Work.

The preparation of finished plans from the field survey was carried on in the Winnipeg office, where an additional room was secured in November for this work, the Red river work and the International Waters, and a considerable amount of draughting will be necessary to bring the plans to date, as a great mass of important information has been gathered. Considerable office work has also been carried on in accumulating data on the question of storage in the upper Winnipeg River basin.

(*c*) GRAND RAPIDS—SASKATCHEWAN RIVER INVESTIGATIONS.

The Winnipeg River power survey, with E. B. Patterson in charge, S. C. O'Grady, first assistant (A. M. Beale having been recalled to Ottawa), H. Wilson, junior assistant, and P. J. Barry, draughtsman, with rodmen and axemen, was detailed to carry on a survey of the Grand rapids of the Saskatchewan river. This work consisted in contouring the banks of the Grand rapids, obtaining a cross-section of the river for estimating cost of dam and the contouring of the banks up to Cross lake to show to what height the development at Grand rapids could be carried. In addition to this detailed survey work, gauges were placed at the head and foot of the falls, and meterings were taken. An assumed datum was used for this survey work, but this year by the use of continuous gauge readings at Grand rapids and on lake Winnipeg, it is expected to correlate the Grand rapids datum to geodetic datum based on mean sea-level, New York, U.S.A. Plans have been prepared of this work and forwarded to head office.

(*d*) RED AND ASSINIBOINE RIVER SURVEYS.

The Red River and Hudson Bay Navigation Association, with representatives from all the cities and villages on the Red river, held their annual meeting in Winnipeg on July 18 and 19, 1912, and at the meeting of the association a committee was appointed consisting of Mayor Waugh and Alderman Midwinter, of Winnipeg, to wait upon the Hon. Robert Rogers, the Minister of the Interior, and ask him for a survey of the Red river from Winnipeg to the international boundary. Mr. Rogers acceded to the wishes of the committee and ordered an immediate commencement of this survey. Later, the Winnipeg and St. Boniface Harbour Commission waited on the Minister and requested that the survey be extended and a harbour survey made of the Red and Assiniboine rivers within the city limits. Approval for this work was granted by the Minister.

G. H. Burnham, B.A.Sc., was placed in charge of field survey party, with D. Cameron and H. J. Woodman, instrument men, B. H. Hughes, leveller, A. M. Reid and G. A. R. Emery, topographers, E. B. Chalmers and W. W. Buchanan, draughtsmen. This staff of engineers, assisted by rodmen and axemen, was placed in the field early in August and carried on the survey work, completing it the first week of January, 1913.

In the city of Winnipeg soundings were taken at cross-sections every 100 feet along the river banks, and the topography was carried up from the water's edge to include the houses at the top of the bank. The traverses were tied in to the special

survey of the city of Winnipeg by the late R. E. Young, D.L.S., and checked very closely on his work. A launch, two row boats and one canoe were purchased to convey the party to and from work; these were also used on the sounding work. The field notes were kept on the standard loose leaf forms and the plotting was carried on in the Winnipeg office; later, the plotting was done in the field, and when a section of the river was completed the notes and field sheet were sent to Winnipeg. A base line of check levels was run by Mr. Hughes and tied in to the geodetic bench marks at Winnipeg, Niverville, Dominion City and Emerson. In November, freeze-up occurred and from that time on the soundings were taken through the ice. In addition to the soundings and contouring of the banks, information was obtained giving the height of high-water marks from floods in former years.

Information Desired and Obtained.

The Navigation Association desire to obtain data that would enable estimates to be made of the probable cost of improving the channel from Winnipeg to the boundary, either by dredging or by the construction of dams similar to the one at St. Andrews, Man. The required data have been secured, but there is much draughting to be done before this field work will be finished on the regular topographic sheets.

(*e*) INTERNATIONAL JOINT COMMISSION REFERENCE REGARDING THE LEVEL OF THE LAKE OF THE WOODS.

In the early eighties, during the construction of the Canadian Pacific railway, considerable industrial development took place along the northern part of the Lake of the Woods, and lumbering, fishing and gold mining led to extensive navigation of the lake. At that time there were three uncontrolled outlets; the eastern outlet now controlled by the Kenora power-house, the western outlet now controlled by the Norman dam, and a third still further west at the site of the old Keewatin Lumber Company, the latter being more properly an overflow channel. These uncontrolled outlets allowed a fluctuation on the lake level of from 10 to 12 feet, which was consequently a serious detriment to navigation in low-water periods. The Ontario government, in 1886, built a dam at the head of the western outlet. In 1888 another outlet, controlled by the power-house of the Lake of the Woods Milling Company was made through a narrow neck of rock separating the lake from the river at Keewatin; a second cut controlled by the same company was made shortly afterwards. In 1894 the Keewatin Power Company commenced the construction of the Norman dam at the western outlet below the Ontario Government dam. This dam was completed in 1898 and the old government dam above removed. The regulation of the dam since that period has been under the control of the Ontario Government.

The construction of the Canadian Northern railway through northern Minnesota, in 1900, led to an influx of settlers to the low-lying lands of the southwestern border of the lake.

In 1907, the Lake of the Woods and the Rainy River Low-water Association was organized at Warroad, with Paul Marschalk as president. The object of this association was to have the level of the Lake of the Woods kept at as low a stage as possible, and the effect of the representation made, was to bring the matter to the attention of the United States Government for adjudication.

Early in the year of 1912, by consent of the Canadian and American Governments, this question of water level on the Lake of the Woods was referred to the International Joint Commission. The reference for their consideration is given herewith:—

Reference.

1. In order to secure the most advantageous use of the waters of the Lake of the Woods and of the waters flowing to and from the lake on each side of the

boundary for domestic and sanitary purposes, for navigation and transportation purposes, for fishing purposes and for power and irrigation purposes, and also to secure the most advantageous use of the shores and harbours of the lake and of the waters flowing into and from the lake, is it practical and desirable to maintain the surface of the lake during the different seasons of the year at a certain stated level, and if so, what level?

2. If a certain stated level is recommended in answer to question No. 1, and if such level is higher than normal or natural level of the lake, to what extent, if at all, would the lake, when maintained at such level, overflow the low lands upon its southern border or elsewhere on its border, and what is the value of the lands which would be submerged?

3. In what way or manner, including the construction and operation of dams or other works at the outlets and inlets of the lake, or in the waters directly or indirectly tributary to the lake or otherwise, is it possible and advisable to regulate the volume, use and outflow of the waters of the lake so as to maintain the level recommended in question No. 1, and by what means or arrangement can the proper construction and operation of regulating works, or a system or method of regulation, be best secured and maintained in order to insure an adequate protection and development of all interests involved on both sides of the boundary, with the least possible damage to all rights and interests, both public and private which may be affected by maintaining the proposed level?

Importance of Regulation of the Lake of the Woods to the Water-powers of the Winnipeg River.

By proper regulation of this lake the powers on the Winnipeg river would be increased some 55 per cent, or from some 276,000 horse-power to 422,000 horse-power marketable power. This would be of great benefit to: The city of Winnipeg's Municipal Power plant, to the Winnipeg Street Railway Company's plant, to the large water-powers owned by the Dominion Government, to the Ontario Government water-powers, to the town of Kenora, to the Keewatin Power Company and to the Lake of the Woods Milling Company. The city of Winnipeg and suburbs has a particular interest in the question before the Commission, as their present supply of cheap hydro-electric power is derived from the Winnipeg river. While proper regulation would be of great benefit, an adverse decision by the Commission would be a corresponding detriment. The importance of this was recognized by the city, the street railway, and the Public Utilities Commission, and the Water-power Branch was requested to co-operate in obtaining the necessary field data for a final united presentation to the International Joint Commission. In order to secure such data it was necessary to extend the storage investigations already undertaken by the Water-power Branch in connection with the upper waters of the Winnipeg river.

A reconnaissance of the watershed from Kettle falls to Point du Bois was made in June last. A memorandum of the hydrographic and other data required was prepared as a result of this reconnaissance, and arrangement made for the data to be secured by the engineers of the Manitoba Hydrographic Survey.

S. S. Scovil, B.Sc., assistant chief engineer, whose residence in Kenora had made him familiar with the district, was detailed for this special and important work. As assistance was required from time to time, the various hydrographers of the Manitoba Hydrographic Survey carried out the field work under him. A. P. Smith was secured as draughtsman for the work. In January, G. J. Lamb was placed at the outlets of the Lake of the Woods in order to secure continuous records of flow, to rate the output of the Kenora power-house, &c., &c.

The International Joint Commission held a preliminary hearing at Kenora in September, 1912, and at this meeting the city of Winnipeg was represented by Isaac Campbell, K.C., Col. H. N. Ruttan, city engineer, Thos. R. Deacon, C.E. (at present

mayor), representing the Winnipeg Board of Trade, and Controller Cockburn; the Winnipeg Street Railway Company was represented by D. H. Laird, K.C., and Manager Phillips, the province of Manitoba by Judge Robson, Public Utilities Commissioner, and the Department of the Interior by J. B. Challies, Superintendent of Water-powers. Mr. Challies submitted a preliminary statement which was substantiated by the other power interests of Manitoba.

Work to be carried out.

A large portion of the material listed in the memorandum prepared at the conclusion of the reconnaissance last June has been secured, but there still remains a considerable amount of field data to be gathered and put in shape. The large amount of information at present to hand requires considerable additional office and field assistance before it can be properly compiled for use in argument before the Commission.

When the data are finally gathered and completely prepared, the city of Winnipeg and other power interests of Manitoba have requested that a conference be held to determine the final joint presentation of argument to the Commission.

(*f*). MISCELLANEOUS POWER REPORTS AND INVESTIGATIONS.

An examination of the Saskatchewan river at Prince Albert was made and the results of estimates of possible maximum flood checked.

Reconnaissance of the Saskatchewan river near Elbow for water-power for use in connection with South Saskatchewan water supply diversion project.

J. B. McRae, consulting engineer, H. E. M. Kensit, electro-mechanical expert, and the undersigned, made a reconnaissance of the South Saskatchewan river from Billing's ferry to the Elbow to determine the possibility of water-power for the pumping required in connection with the proposed South Saskatchewan water supply diversion project.

The figures of low water flow furnished by the Irrigation Branch at Calgary showed that a minimum flow of about half that estimated as necessary for the pumping might be expected. In addition to this, Mr. Muckleson, assistant chief engineer, C.P.R. Natural Resources Department, advised us that the large C.P.R. Irrigation scheme at Bassano had rights that would further reduce this low flow. In view of these facts it was not thought advisable to proceed with further surveys on the Saskatchewan river until hydrographic data had been gathered to show whether there would be sufficient water to enable a water-power development to compete with power from other sources.

Manigotagan Power Survey.

A reconnaissance was made by Assistant Engineer G. J. Lamb, of the two lower falls on the Manigotagan river, and report as to feasibility of development at this point was submitted to head office.

Convention of District Engineers, United States Geological Survey, Washington, D.C.

The undersigned attended the convention of the District Engineers of the United States Geological Survey, held January 6 to January 11 at Washington, D.C. At this conference every phase of hydrographic work carried on by the United States Geological Survey was discussed, and as the engineers of this survey have had vast experience on this work, the opportunity of absorbing ideas from the various district engineers was of great value. The undersigned had the honour to be placed on a committee of three selected to draw up a table of contents for the manual that will be prepared for the United States service.

(*g*) RECOMMENDATIONS.

1. *Evaporation stations.*—In connection with the investigations on the international waters, it was found advisable to install an evaporation station on the Lake of the Woods at Keewatin, and I would recommend that similar stations be installed throughout the province at various points so that this factor which vitally affects stream flow may be carefully studied. These additional stations need not all be as fully equipped as that on the Lake of the Woods, at which place the equipment consists of:—

1. Galvanized evaporation tank with brass pointer and measuring cups.
2. One Howard rain gauge.
3. One thermometer for water temperatures.
4. One recording thermometer.
5. One recording barometer.
6. Wind gauge of the Robertson type.
7. Hygrometer will be added so that data may be collected on the effect of humidity on the evaporation at this station.

2. *Automatic gauges.*—In obtaining a continuous accurate record of the flow on the Winnipeg river at Point du Bois, it is now necessary to install an automatic gauge at the metering section at Slave falls; this necessity arises from the fact that fluctuations in gauge height are now caused by the operation of the city power plant at Point du Bois. Another recording gauge should be installed at the gauging station at North Tunnel Island No. 16, as the flow at this point is affected more or less by operation of the Keewatin mills, the Norman dam, &c., &c. Four small Gurley gauges for recording the opening and closing of the gate valves on water-wheels should also be secured for the Kenora power plant so that a continuous and accurate record of flow may be obtained at that point.

3. *Further or new power surveys.*—Surveys showing the possible powers on the Assiniboine and Little Saskatchewan rivers in the vicinity of Brandon should be undertaken in order to determine the power available for Brandon and that section of country. Similar surveys should be carried on of the Mossy and Valley rivers and at Meadow portage in order to secure this data for the district tributary to Dauphin.

The Manigotagan river should have a further reconnaissance survey which will show the powers of that river and the storage possibilities affecting the powers at the mouth of the river.

A reconnaissance survey should be carried on of the Churchill river in order to obtain preliminary data that would be of value when the Hudson Bay railway is constructed.

Work on the Nelson river should be commenced immediately, as these powers will be of value on the completion of the Hudson Bay railway and these powers are at present a matter of particular interest to the province of Manitoba. During the last session, the leader of the Opposition drew the Government's attention to the importance of the water-powers in Manitoba and referred particularly to the Nelson river powers, and a resolution was addressed to the Public Utilities Commissioner of the province, which is as follows:—

> '*Resolved:* That in the opinion of this House it is expedient to refer to the Public Utilities Commissioner for investigation and report at as early a date as possible consistent with his other duties and inquiries, the question of development of publicly owned hydro-electric power within the province, with a view to securing for all sections of the province, rural as well as urban, the inestimable benefits and conveniences now enjoyed by the citizens of Winnipeg as the result of the wise expenditure of public money for power development and distribution.'

4. *Additions to staff.*—With the increase of work an accountant is required; a permanent stenographer and office assistant should also be obtained. The services of a computer are required for the preparation of international waters data and the checking of meter notes. Four additional draughtsmen are required to complete the Red river draughting, to bring the Winnipeg river work up-to-date and to prepare information required for the brief to be submitted to the International Joint Commission. Three additional hydrographers should be secured in order to extend the hydrographic work through the province and obtain records that will be needed within the next few years.

5. *Underground waters of Manitoba.*—The rainfall of Manitoba is abundant, averaging about 20 inches a year. The streams, however, in the southern portion of the province are rather far apart and springs are few and of small volume. Moreover, the surface waters are in many localities badly polluted by sewage and industrial wastes, being entirely unfit for drinking. For these reasons carefully protected ground-water supplies are highly desirable for domestic uses, especially in towns and villages, where shallow wells may be rendered unsafe as sources of domestic supply on account of local contamination, such as barns, privies, cesspools, &c.

Not only is the problem of procuring pure water for drinking and domestic purposes recognized as urgent in towns and villages of this province, but it is of great importance on the prairie farms. Many farm wells are located close to stables or barns and are contaminated by refuse blown or thrown into them as well as by bodies of small burrow animals that fall into them when searching for water during dry seasons. Many such wells also receive the drainage from farm buildings. To the farmer, therefore, information both as to the proper construction and location of wells and as to the best sources of water would be of great value.

One of the most important uses of water in this prairie country is for locomotive boilers, satisfactory supplies are secured in many cases from surface streams; but suitable streams are few and far apart and may go dry in times of drought. In such localities wells are the only sources of supply.

Many thousands of dollars have been expended to date in well-drilling in Manitoba, but knowledge of the conditions that determine the success or otherwise of these wells is scanty. Information regarding the cost and construction of these successful wells should be collected and published in permanent accessible form for general use.

No specific attempt at any systematic study of the underground waters of Manitoba has so far been made, although exhaustive researches have been made under the direction of Col. Ruttan, the city engineer of Winnipeg. The domestic water supply of the city of Winnipeg is now secured from artesian wells.

I would recommend that serious consideration be given to the advisability of a study by the Manitoba Hydrographic Survey of the underground waters of Manitoba. The work involved would include the geologic tracing and correlation of the rock formations, studies of the water-bearing capacities of each formation outcropping at the surface or encountered by wells, the determination of the depth and yield of the waters, the study of the mineral springs, the investigation of the public water supplies, particularly the artesian well system of the city of Winnipeg, the procuring and tabulating of information respecting wells now in use, whether deep or shallow, methods employed in their construction. The chemical work would include field examinations of waters and determinations of the carbonates, sulphates, chlorides, and iron. Complete analysis should be also made of typical well waters with special attention to the sanitary quality of the water, with a view to determining sources of pollution and to making recommendations as to their removal. Arrangements would have to be made for the co-operation and assistance of a geologist and a chemist. Such assistance could be probably obtained from the technical staff of Manitoba University and as the field work could be done during the summer vacation the regular work of the University would not be interfered with.

I would estimate the cost of this work would be about $3,800, made up as follows:—

Instruments and special supplies	$ 300 00
Services of a chemist, portion of time, and incidental expenses for four months, say	500 00
Services of a geologist for vacation all time, at $150 per month, and field for four months, say	900 00
Clerical assistance and stenographer	300 00
Extra field investigations of district hydrographers incidental to this work, say	500 00
Incidentals	300 00
Editing and printing of report, with maps	1,000 00
Total	$ 3,800 00

APPRECIATION OF THE EXCELLENT WORK OF THE STAFF.

In conclusion, hearty thanks and appreciation is extended to the members of the staff for their loyal and conscientious co-operation which, combined with the efficient direction from head office (Ottawa), has made it possible to carry on during 1912-13 a most successful and extensive season's work.

I have the honour to be, Sir,
Your obedient servant,

DOUGLAS L. McLEAN,
Chief Engineer.

No. 7.

REPORT OF M. C. HENDRY.

OTTAWA, March 31, 1913.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water-power Branch,
Ottawa.

SIR,—I have the honour to submit the following as a summary report of the work carried on under my supervision during the year ending March 31, 1913. The primary purpose of the season's work was to complete the investigations on the Bow river; this was completed and a complete report is in course of preparation.

ORGANIZATION.

Headquarters were established in Banff and about May 15 a party in charge of Mr. C. H. Attwood commenced work at Bow Fort creek. About August 10 Mr. Attwood, with Mr. D. B. Gow as assistant, was detached with a small party to make a survey of Grand rapids on the Athabasca river; this was completed about September 15.

Mr. K. H. Smith acted as resident engineer at Minnewanka dam until early in July, when he left for the Spray lake in charge of a small party.

Messrs. Cotton, Dafoe and Hogarth acted as junior assistants during the season, and returned to college early in October, as did Mr. Attwood. Messrs. Smith and Gow returned with me to Ottawa in October and were engaged during the winter months in plotting and compiling the notes taken in the field.

The undersigned generally supervised the work, making several reconnaissance trips during the season, both alone and with Mr. C. H. Mitchell, the department's consulting engineer for this work.

Certain power applications in the province were also visited and reported upon.

BOW RIVER WATER POWERS.

The Bow river, west of Calgary, drains an area of 3,138 square miles, 1,710 of which are above Kananaski falls and lie wholly in the Rocky mountains. (See contour plan of Bow River basin which accompanies this report.) It is a typical mountain stream rising at an altitude of some 6,500 feet, the slope of the river is very steep and several falls occur; like other mountain streams, its flow is subject to sudden variations and is greatly affected by the temperature. During the hot summer months of June and July the melting of the snow in the mountains causes floods, while the cold during the winter reduces the flow to very small proportions. The variation between high and low water is very great and, though no direct gaugings of flood discharge are available, levels taken by the Canadian Pacific railway at their bridges over the Bow and Kananaskis rivers lead to the belief that a flow as high as 45,000 c.f.s. has occurred at Horseshoe falls; a winter discharge of less than 500 c. f. s. was recently recorded at the same place.

What may be called the power section of the Bow (see Plate 3) is well within economic transmission distance of Calgary, and is some thirty miles in length. Calgary, the logical power market, is the centre of a large district, and its growth has been phenomenal owing to its strategic position as a distributing and manufacturing centre; controlling as it does its own public utilities, the city itself uses an ever increasing amount of power for street lighting, street railway and waterworks, and the possibilities of the power market are increased by the pressure nearby of the recently erected Canadian Pacific car shops, and by the two cement plants. There are amongst others some plants handling clay products, and it cannot be doubted that many other factories will follow the advent of cheap power.

The Bow river is the first of the Rocky Mountain streams investigated by the Water-power Branch of the Department of the Interior. Early in 1911 there were several conflicting applications for power rights, with which this branch had to deal; there was, too, an increasing demand for cheap power in Calgary; it was necessary, therefore, to obtain definite, reliable and independent information of all phases of the power situation. Especial study of storage possibilities was necessary, for, owing to the great fluctuation in the discharge, the amount of power available during the low-water season under natural conditions, would be but a fraction of that available during the remainder of the year.

A thorough investigation into the power and storage possibilities of the Bow river, west of Calgary, and including all its tributaries, has been concluded by the undersigned, working under the general advice and direction of Mr. C. H. Mitchell, C.E., consulting engineer to the Water-power Branch. A thorough reconnaissance of the whole basin was made, followed by surveys of all possible power sites and storage basins. As run-off data at critical points were lacking, both in the river and its tributaries, additional gauging stations were established at the instance and expense of the Water-power Branch; most of the previous work of stream gauging had been carried on only during the opening water season, and little data were available as to the flow during the winter months.

The work instituted in the summer of 1911 was continued and completed in 1912. In the two seasons the following was accomplished:—

Reconnaissance.

A reconnaisance was made of the following by the undersigned accompanied, in most cases, by Mr. Mitchell: Kananaskis river and Kananaskis lakes; Spray river and

tributaries and the Spray lakes; Bow lake, Hector lake, Pipestone creek, Baker lake, Ptarmigan lake, Redoubt lake, Johnson creek, Redearth creek, Brewster creek, Forty-mile creek and Ghost river; and a thorough reconnaissance, preliminary to the survey, on the power-producing portion of the Bow river was also made. The different creeks and lakes examined in these trips were either eliminated as being unsuitable for power or storage purposes, or accepted as feasible and some general scheme for the development settled on and a field party put on the ground to carry out the investigations in the detail required.

Surveys.

During the seasons of 1911-12, a detailed topographical survey was made of about 30 miles of the Bow river from Canadian Pacific railway bridge above Kananaskis falls down, particular attention being given to the several power sites; topographical surveys were also made of Bow lake, Lake Minnewanka and the basin of the Spray lakes, with a view to the creation of storage.

The results of these surveys may be summarized as follows:—

* STORAGE BASINS.

Basin.	Elevation above sea level.	Miles from Calgary.	Capacity.
Bow lake	6,503	111	27,400 ac. ft.
Spray lake	5,200	58	171,000 "
Lake Minnewanka created	4,728	63	44,700 "
" " auxiliary	4,724	63	14,200 "
Total above Calgary on Bow river	....	....	243,100 "

* See general plan.

* *Power Sites.*

Site.	Elevation crest of Dam.	Miles from Calgary.	Head.	Remarks.
Bow River.				
1. Kananaskis Falls	4,155	43	70 ft.	Building.
2. Horseshoe Falls	4,082	42	70 "	In operation.
3. Bow Fort	4,010	40	66 "	Prospective.
4. Mission	3,865	33	47 "	"
5. Ghost	3,812·5	30	50 "	"
6. Radnor	3,760	31	44 "	"
Cascade River				
7. Minnewanka Dam	4,727	63	64 "	"

Total head available . . . . 411 feet.

* See general plan and plates 3 and 19 to 28.

In addition, it is possible to develop power at several points on the Spray river below the proposed storage dam, but as these have not been investigated, the heads are not included.

Benefits of Storage.

All possible storage on the Bow river above Calgary is fortunately available for the whole power reach of the river between Kananaskis falls and Radnor. The mean flow for the low-water months, as recorded at Horseshoe falls, has been found to be as low as 745 cubic feet square and the minimum flow as low as 500 c.f.s., by means of the storage that has been, and may be, created, it is anticipated that the mean flow can be raised to at least 1,500 second feet, which, below the mouth of the Ghost would be increased to 1,600 c.f.s.

The effect of storage upon the power output of the river over that due to the natural flow, is shown by the following tables:—

TABLE SHOWING EFFECT OF REGULATION AT EACH POWER SITE ON BOW RIVER.

Power Site.	Continuous Wheel Horse-power.	
	Natural Flow.	Regulated Flow.
1 Kananaskis falls	3,820	9,545
2 Horseshoe falls	3,820	9,545
3 Bow Fort	3,600	9,000
4 Mission	2,565	6,410
5 Ghost	3,780	7,270
6 Radnor	2,800	6,400
Total	19,785	48,170

	Wheel Horse-Power.
Government power site at Minnewanka dam, Cascade river	1,165
Grand total of power capacity of river fully regulated	49,335
Giving an increased continuous output of	28,395

TABLE No. 4.—Summary of Effects of Storage in the Bow River Basin upon Developed and Undeveloped Water Powers.

Location.	Natural Flow.										Regulated Flow.			
	Elevation of crest of dam.	Working Head.	Rated H. P. of Turbine.	H.P. Steam Auxiliary	Min. Monthly Flow C.F.S.	Available H.P. with flow of Col. 6.	H.P. Years available in average year.	Possible Turbine output 24 hour power 60% of time.	H.P. Years available from water, with wheel capacity Col. 9.	H.P. Years added within present capacity of wheels.	Min. Regulated Flow C.F.S.	Possible Turbine output 24 hour power 60% of time.	H.P. Years available from water with wheel capacity Col. 13.	Continuous H.P. available with flow in Col. 12.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Developed.														
1. Kananaskis Falls	4155	70′	10000	....	720	4580	8095	7400	6643	1870	1500	11110	10754	9545
2. Horseshoe Falls	4082	70′	19700	....	720	4580	12087	7400	6643	2171	1500	11110	10754	9545
Undeveloped.														
3. Bow Fort	4010	66′	*13200	....	720	4320	7407	6950	6262	2053	1500	10420	10089	9000
4. Mission	3865	47′	*10500	....	720	3760	5277	4930	4450	1493	1500	7510	7260	6410
5. Ghost	3812·5	50′	*10500	....	820	3730	6085	5710	5194	1542	1600	8420	8150	7273
6. Radnor	3760	44′	*10500	....	820	3280	5345	4589	4589	1373	1600	7450	7210	6400

*These capacities are taken arbitrarily for the proposed equipment to be installed.
They provide for 44 per cent to 64 per cent over development to take care of load fluctuations.

Cost data.

The following estimates of the cost of creating the different storage basins, of the cost of developing power at the different power sites on the Bow river, and estimated price for delivering power in Calgary from the several plants have been prepared:—

STORAGE.

Site.	Capacity.	Estimated Cost.	Cost per acre foot.
		$	$ cts.
Bow lake	27,400 acre feet.	105,000	3 83
Spray lake	171,000 " "	500,000	2 98
Minnewanka	44,000 " "	110,000	2 50
Lake Louise	....	....	....

POWER.

Site.	Head in feet.	Continuous output wheel h.p.	Estimated cost of plant complete excluding cost of storage.	Estimated cost per k.w. hour power delivered Calgary on 50% load factor basis including proportion of cost of storage.
Bow Fort	66	9,000	$846,800	.49 cents.
Mission	47	6,410	812,800	.60 cents.
Ghost	50	7,270	852,700	.56 cents.
Radnor	44	6,400	773,500	.58 cents.

These estimates include the cost of a transmission line to Calgary of a capacity to serve the four plants, but they are preliminary only, and it is expected that final figures will show the situation in a more favourable light.

A report upon the power question in Calgary was published recently and it is interesting to note that the cost per k.w. hour on a 50 per cent load factor basis has been estimated to vary from 0·85 cents to 0·74 cents for a steam, coal-fired plant, according to the capacity of the station.

ELBOW RIVER SURVEYS.

The Elbow river forms one of the main tributaries of, and enters the Bow river within the boundaries of the city of Calgary. Its source is near that of several other streams which contribute their waters to the Bow river above Calgary.

A study of the power and storage of the Bow river, which did not include the Elbow, would be incomplete; also, prior to the spring of 1911 several applications for power rights on this stream had been filed with the department. While different schemes of development were proposed, they all covered the same stretch of river, and so no settlement was possible without an investigation on the ground. Accordingly, in May, 1911, a reconnaissance was made by Mr. C. H. Mitchell and the undersigned, and after several combinations were carefully considered a general scheme of development was arrived at. Later, a field party was put on the ground and a survey made of the part of the river in question, with sufficient detail to permit of a study of a method of development. From the information so gathered a development was worked out by Mr. Mitchell and embodied in a report submitted by him to the department.

In this report it is pointed out that any development on the river would be of such high unit cost and the amount of power secured would be so small that it would have to be utilized near the point at which it was generated. The method of development recommended involves the building of two dams, a flume line about 1¾ miles long, together with a regulating basin, penstocks and power house; the gross head developed would be 225 feet, of which it is expected at least 215 feet would be available for producing power. Owing to the great variation in the flow of the river, regulation would be necessary and one of the dams is proposed to create a storage basin above the development; the basin created would be capable of storing 23,000 acre feet which it is estimated would be sufficient to insure a flow of at least 200 c. f. s. at the plant; this basin would be in sections 28 and 33, township 21, range 6, west of the 5th, and the dam near the east boundary of section 5, township 22, range 6, west of the 5th. The second dam, called the Power dam, would raise the water into the proposed flume and would be situated in the S.W. ¼ section 15, township 22, range 6, west of the 5th; the power station would be situated on the river below an island in the S.E. ¼ section 14, township 22, range 6, west of the 5th.

In this scheme, and with the head and flow stated, it would be possible to produce about 3,600 continuous electrical horse-power and during part of the year the output would be increased to from 3,800 to 4,200 horse-power by the use of more water. Power so developed could be utilized in the immediate district in mining and other operations, as there is evidence of the presence of considerable mineral deposits in the region.

To recapitulate, the development of the Elbow river for power purposes requires a storage dam, a power dam, flume line, etc., creating a storage of 23,000 acre feet, a head of 225 feet gross, and producing 3,600 continuous electrical horse-power.

Minnewanka Storage.

During the winter of 1911-12 an agreement was entered into between the Calgary Power Company and the Department of the Interior whereby the former were given the right to create storage at lake Minnewanka. As the basin draining into the lake lies wholly within the boundaries of the Rocky Mountains Park, the park interests had also to be protected; these, as well as others involved, were covered by the terms of the agreement.

Under the agreement, the company were permitted to raise the level of the lake 12 feet and utilize the water so impounded for power purposes on the Bow river during the low-water period. The undertaking involved the construction of a dam in what is known as the 'Devil's canyon' just below the junction of Devil's creek, the outlet of lake Minnewanka, and Cascade creek; the clearing of about 600 acres of land of timber brush, etc.; road diversion and bridge across Devil's creek; survey of a new site for villa lots on the shores of the lake; building a new wharf together with slips, and two marine railways for the boats on the lake.

Work was commenced upon the undertaking in the early part of March, 1911, Mr. K. H. Smith being appointed inspecting engineer; the work of clearing the timber inside the flood line, diverting the road, and building the dam was carried out simultaneously. (See Plates 23 to 25.)

The dam, a solid concrete structure about 100 feet long, and 55 feet in extreme height, was provided with three stoplog sluiceways and a low-level sluice controlled by a gate valve; this was the largest part of the undertaking, as it was necessary to take care of the water flowing from the lake and Cascade river while building the dam; it was also desirable to complete the work in time to impound at least part of the flood water and provide storage for use in the winter of 1912-13. By exercising great diligence and care the dam was successfully completed by May, 1912, and storage commenced; some clearing remained to be done but was to be finished during the coming season.

While the dam was building the department took advantage of the opportunity to have incorporated in the work a steel thimble to act as entrance to a penstock, for it is intended, at some future date, to generate electric power below the dam for use in the park, making use of the storage dam as headworks for the plant. A minimum flow of 150 second feet has been secured to the government for this purpose by the terms of the agreement, and it is expected that a head of 64 feet can be developed which, with the flow of 150 second feet, would give an output in wheel horse-power of about 870 horse-power.

Surveys were made during the summer of 1912 of the proposed site and preliminary plans of the development are at present being prepared.

It is proposed to transmit the power to Banff, a distance of about 8 miles, where it will be used for street lighting, which will be made a feature of the place, besides selling power to the hotels and other customers.

LAKE LOUISE POWER PROJECT.

An interesting power development in the Bow basin is that operated by the the Canadian Pacific railway in connection with the hotel at lake Louise, near Laggan: this plant supplies light to the hotel at the lake, the station and surrounding houses and buildings; during the summer of 1912, the plant was enlarged and changed, and the output of the station increased.

The original plant was operated under a head of 45 feet, obtained by means of a concrete dam 75 feet long built across the bed of Louise creek about a quarter of a mile below the outlet of the lake; from the intake a 16-inch wooden stave pressure pipe leads to the power house situated further down the creek, the head obtained being secured by the natural fall in the creek. A 35-k.w. machine belted to the turbine, together with a switchboard, formed the station equipment.

The new installation, rendered necessary by the increased hotel accommodation, involves a concrete dam placed at the outlet of the lake, and forming part of the intake. The structure is in the nature of a bridge having the spill sections situated between the piers, and is so built that the former high, low and normal levels of the lake will still obtain.

Leading from the intake to the present power house is a 20-inch wooden stave pressure pipe line about 1,800 feet long, and giving a total head at the plant of 130 feet.

A power house has been enlarged and a new unit connected to a generator of 75 k.w. installed, which, together with the other unit, will give an output of about 130 horse-power.

The accompanying photos illustrate the different features of the undertaking.

KANANASKIS FALLS DEVELOPMENT.

In 1912 the Calgary Power Company were given the right to develop power at Kananaskis falls, on the Bow river, about two miles and a half above the Horse-shoe Falls plant, a total drop of about 40 feet existing at that point, which may be increased an extra thirty feet, without excessive flooding, by means of a dam at the top of the falls, giving a total head of 70 feet.

The work done by the field party of the Water-power Branch operating in this district in 1911 had already covered this ground so that the department was in a position to deal with the application.

During the late fall of 1912 the company carried out surveys of the site in considerable detail upon which designs for the plant were worked out. The layout shows a dam across the head of the falls immediately below the point at which the Kananaskis river empties into the Bow, a canal on the north side of the river, an intake or forebay, wheel pit, power house, and tailrace tunnels which will deliver the water back to the river below the falls. (Plates 26 to 28.)

The dam will be a solid concrete structure, 725 feet long, having an inspection tunnel running throughout its length. Special precautions will be taken to guard against possible leakage under the structure through seams in the underlying rock, similar precautions being taken where the structure joins the river bank. There will be eleven sluiceways, 18 feet wide and 14 feet below the spillway level; the spillway section will be divided into twelve 17-foot openings, and in addition there will be a low-level sluice-way controlled by a 72-inch valve; this will provide for a flood discharge of over 47,000 c.f.s. with a 3-foot overtop on the spillway section.

The canal will be of sufficient dimensions to carry the amount of water necessary for the maximum output of the plant at low velocity. The design of the intake and power house have not yet been settled upon except in a general way, but the station equipment will consist of two units; these will be vertical shaft, re-action turbines directly connected to two vertical shaft generators each of 3,750 k.v.a. capacity operating at 12,000 volts, three phase, sixty cycles, and giving a station capacity of 10,000 horse-power. The plant will be connected to the Horseshoe Falls plant through the Exshaw transmission line, step-up transformers being eliminated at this station.

The necessary plant for building this power station reached the ground early in March, 1913, preliminaries are being rapidly pushed; the engineers expect to have the plant in operation by November of the present year, and thus be in position to assist in carrying the power load during the low water period of 1913-14. With the two plants in operation the company will be in a position to deliver, with the present storage capacity, a continuous output of 11,600 wheel horse-power.

HORSESHOE FALLS POWER PLANT.

At the Horseshoe falls on the Bow, about 50 miles west of Calgary, the Calgary Power Company has built a hydro-electric power plant, which consists of a dam, intake, power house, etc., all of permanent construction; the head developed is 70 feet, part of which is due to the actual fall, and part to the slope of the river. (Plates 19 to 22.)

The dam is of solid concrete construction of the spillway type, 140 feet long on the crest. In addition to this spillway the dam is provided with four stoplog openings and four sluiceways controlled by gates of the Stoney type, making ample provision for discharging any flood liable to occur. In building, precautions were taken to take care of leakage by means of a drainage tunnel and measures were adopted to reduce the leakage through the underlying rock to a minimum.

The intake is provided with racks and ice clearing devices and gives entrance to four penstocks, two 9·5 feet in diameter and two 12 feet in diameter.

The power station is designed for four units and two exciter units. Two main units are capable of developing 3,750 wheel horse-power and two of 6,000 wheel horse-power each; the two smaller units were first installed and the installation of the second of the larger units is under way; when completed, the station will have a plant capable of giving an output of 19,500 wheel horse-power or 18,000 E.H.P.

Owing to the variation in flow of the river this cannot be considered as continuous output. From the records available it is concluded that, with the present storage developed at lake Minnewanka, a continuous output of about 5,800 wheel horse-power may be expected. The investigations carried out by the branch during the last two years, and completed last season, lead to the belief that this may be very materially increased by the creation of additional storage at other points in the basin.

The Calgary Power Company have two transmission lines running to Calgary and one to Exshaw from their Horseshoe Falls plant.

Last summer a final inspection of the plant was made by Mr. C. H. Mitchell, consulting engineer to the Water-power Branch, and he recommends in his report that: 'Approval be now given by the department for the design and construction of the works in their entirety in so far as the department is concerned in the various matters involved.'

MISCELLANEOUS INSPECTIONS.

During the year 1912-1913 several power ties were visited and reported upon, these were: Rocky rapids, Saskatchewan river; McLeod river, near Edson; Sturgeon river, near Fort Saskatchewan; and the St. Mary's river, near the international boundary.

Rocky Rapids.

Rocky rapids is on the Saskatchewan about 75 miles west of Edmonton; at this possible power site practically all the head would be created by means of a dam, the rapids being flat and the river wide. Although, no doubt, there is rock underlying the river bed, it is covered to a considerable depth with gravel and sand; the rock forming the bank at this point is a very soft sandstone and resembles cemented sand more than rock. The river flows through a wide valley formed by banks from 150 to 200 feet high and has in many places wide bottom lands, most of which are well timbered with spruce and poplar.

To create a head of 50 feet, a dam about 1,800 feet long would be necessary, and some provision such as a lock would have to be made for navigation.

The nearest market for power is Edmonton, 75 miles distant, where, no doubt, considerable power could be disposed of.

The discharge of the Saskatchewan river is similar to that of all the streams on the eastern slope of the Rockies, the flow during the low-water period being a very small proportion of the high-water flow and varying greatly with the temperature; the high-water period corresponds to the time of high temperature, while the low flow occurs during the winter months. While the daily gauge heights have been obtained at Edmonton for nine years, data on the actual discharge of the river are rather limited, the highest flood of which there is record occurred nine years ago, and an estimate of the discharge at that time places it at 180,000 c.f.s.; in June, 1908, a discharge of 88,000 c.f.s. was recorded, while a low-water discharge has been noted, at the same place, of 1,546 c.f.s. It has been assumed that nearly the same flow could be obtained at Rocky rapids, say 1,400 c.f.s., that is with a head of 50 feet there would be available about 6,400 B.H.P. continuous power.

An output as above would not justify the expenditure necessary to build a plant at this point, especially with a power market situated as close to coal deposits as Edmonton, and the power question needs most careful consideration before any hydro-electric development is decided upon.

McLeod River.

At a point on the McLeod river about 3 miles from Edson and just above the mouth of Moose creek, there is a possible power site; this was investigated in July, 1912.

The McLeod river, which rises on the eastern slope of the Rocky mountains and is one of the tributaries of the Athabaska, and has a drainage area of nearly 1,800 square miles, but as the greater part of this lies in unsurveyed territory, there is little definite information concerning it. This river has the characteristic flow of all streams with mountain sources, and has a special reputation with the lumbermen operating in the district for variable flow, drives of logs being frequently tied up owing to its sudden fluctuations. Very little of the drainage area is settled, and practically no waggon roads exist. The site itself lies about midway between the Canadian Northern railway and the Grand Trunk Pacific, and it is likely that the route of easiest access to the site would be from the Canadian Northern railway.

At the time the examination was made a gauging of the river was also taken, and this, together with evidence of high and low water and precipitation, are the only available data on which to base an estimate of discharge. The high-water discharge

has been placed at 20,000 c.f.s., the actual gauging made on August 9, 1912, gave a discharge of 2,100 c.f.s., and it is estimated that the minimum flow is about 300 c.f.s., though it is likely that, at times, even a lower discharge than that occurs.

At the site there is a rapid about one-third of a mile long and having a total fall of 16 feet; by placing a dam near the head of the rapid and raising the water into a pipe line, an additional 14 feet could be secured, giving a total head of 30 feet. The dam would be 800 feet long built upon solid rock for its full length and the pipe line nearly 1,000 feet long, leading to the power house placed at the foot of the rapids. Considerable land would be flooded in this scheme.

It is estimated that a continuous output of about 720 E.H.P. could be secured.

The power market is that to be found at Edson, a divisional point on the Grand Trunk Pacific, having a population of from 500 to 750.

The power necessary for operating and lighting the plant of the divisional shops is generated by steam, coal being obtained from the Brazeau district, which is a few miles away, and it is therefore questionable whether the water power can compete with power developed from coal by steam or producer gas.

Sturgeon River, Fort Saskatchewan Plant.

During 1910-11 the town of Fort Saskatchewan built a hydro-electric plant on the Sturgeon river. The plant installed consisted of a 250 horse-power turbine directly connected to a 150 k.w. generator, a 60-cycle 3-phase machine operating at a 164 r.p.m. and delivering current direct to the line at a pressure of 6,600 volts.

The site chosen was about three-quarters of a mile from the mouth of the river at a point where the river forms a large bow; a timber dam with earth embankment was placed at the upper end of this bow and the water carried across the neck of land in a canal leading to the wheel chamber and from the draft tube through a short channel to the river again. The total head developed was 23 feet.

No records are available regarding the discharge of the river, but estimates made place the maximum discharge at 4,000 c.f.s. while, during the winter of 1911-12, from records of the plant's output it appears that a flow as low as 30 c.f.s. was reached.

In April, 1912, a break at the headworks of the canal occurred and developed so rapidly that the whole canal was cut down, the wheel chamber undermined and the headworks washed out, putting the plant out of commission. In June, an inspection was made and certain recommendations made to the town in respect to repairing and improving the plant, but up to the present nothing has been done towards placing it in running condition.

Grand Rapids, Athabaska River.

In August, 1912, a party was detached from the Bow river survey, with C. H. Attwood in charge, and proceeded by rail and stage to Athabaska Landing and there secured canoes and supplies, together with a canoeman. From Athabaska Landing the trip was made down to Grand rapids in three days.

A survey in sufficient detail for preliminary study was made of the river immediately above and below and including Grand rapids and the island; also, while at the site, a gauging section was established and several meterings were made, a Price current meter being used; while the work was being carried on, the highest flood stage of the river for the season 1912 occurred and a gauging was taken at that time. The return trip to Athabaska Landing was accomplished with some difficulty, it being necessary to 'track' upstream, and occupied ten days. The field notes were plotted up, and the meterings worked out on return to the office in the fall.

Information, in addition to that obtained at Grand rapids, with regard to discharge is meagre, especially for the winter months; during January, February and March a few gaugings were made by the officers of the Irrigation Branch at Athabaska Landing and are available.

From a study of the data secured it appears that a head of about 45 feet could be developed at this point on the river; a dam of from 1,500 to 1,800 feet long, depending upon the position chosen, would have to be built, of which part could be built upon the island which divides the river into two channels at this point. The western channel is the larger; the one on the east side is the boat channel, and in any development at this point, it is likely that a lock would have to be provided to pass the boats up or down the stream.

The banks of the river both above and below the rapids are very high, rising steeply almost from the water's edge except at a few places, notably below the island, where a few small flats exist at the bottom of the bank. The banks at the rapids are composed of a very soft sandstone overlaid with clay, and the bed of the river is thickly strewn with large boulders, many of which are almost spherical.

The discharge of the Athabaska river varies greatly, the greatest flow actually gauged was that obtained by the field party last August, giving a discharge of nearly 63,000 c. f. s., but from high-water marks located and other information it has been estimated that the flood discharge has been as much as 110,000 c. f. s.

The low-water flow at Grand rapids would be about the same as that at Athabaska Landing, as no very considerable streams enter between these two points. A gauging at the latter place made on March 29 gave a discharge of 2,368 c. f. s., while one made in February gave 2,830 c.f.s., so that it would be safe to assume that at the rapids the flow is as low as 2,500 c. f. s., and possibly lower for short periods; this discharge would be the governing factor in the continuous output of a plant so that with a head of 45 feet the maximum continuous output would be 10,200 B.H.P. If this low-water flow could be raised to, say, 7,500 c. f. s. by storage upon some of the lakes tributary to the river, the value of the site would be increased proportionately.

The development of the river at Grand rapids would be a large undertaking, the nearest point at which power could be utilized, at present, is Athabaska Landing, where the demand is small; Edmonton offers the best market, but the distance, in the neighbourhood of 200 miles, is excessive. The dam involved is large, about 1,800 feet long and averaging 35 feet high, also there is a lock to be provided, channel to be dredged, &c.; owing to the low flow and to the expensive nature of the development, the site is not an attractive one as a source of power for a distant market. It might be found advantageous to develop the site if a market could be developed in which the demand would vary with output, say, a pulp mill. If investigations show that storage can be developed economically and the flow increased to 7,500 c.f.s. during the low-water period the increased power, 30,600 B.H.P., would make the proposition more attractive.

In conclusion, I wish to take the opportunity of acknowledging the excellence of the work done by members of my staff.

I have the honour to be, Sir,
Your obedient servant,

M. C. HENDRY,
Chief Engineer.

No. 8.

REPORT OF R. S. STRONACH.

COQUITLAM DAM,
WESTMINSTER JUNCTION, B.C., March 31, 1913.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water-power Branch,
Ottawa.

SIR,—I have the honour to submit the following report of my work during the past year as resident engineer for the Water-power Branch of the Department of the Interior on the construction of the Coquitlam dam.

The Coquitlam dam is being constructed by the Vancouver Power Company, which is a subsidiary company of the British Columbia Electric Railway Company, the development being necessitated by the increase in the power load caused by the rapid growth of Vancouver and surrounding district during the past few years.

The original development, completed in 1906, consisted of a rock-filled timber crib dam, raising the lake level 10 feet, or to elevation 433·0, a tunnel 12,775 feet long with a sectional area of 81 square feet and a fall of 33 feet connecting lake Coquitlam with lake Buntzen, a small concrete dam at the latter lake and steel pipes, 1,800 feet long connecting lake Buntzen to the power house at sea-level on Burrard inlet, a static head of 400 feet being thus obtained and 18,000 k.w. developed; transmission lines connected the power house to Vancouver, New Westminster and surrounding districts.

This development was unable to meet the increasing demand for power and in June, 1909, the department was asked by the company to approve of their constructing a large earth dam, of the hydraulic fill type, on a site immediately below the existing timber crib dam.

In March, 1910, the department authorized the company to proceed with the construction of an hydraulic fill dam, according to plans which were to be submited to and approved by the department before construction was commenced. (See Plates 16 to 18.)

Coquitlam lake is the source from which the domestic water supply of the city of New Westminster, Burnaby, Lulu island and other municipalities is drawn; also there was a strong prejudice against the hydraulic fill type of dam, which was practically unknown in Canada, the inhabitants of the district below lake Coquitlam being especially opposed to this type of structure.

In order to allay the public alarm and also to ensure the preservation of the purity of the water supply for New Westminster and surrounding municipalities, the Government appointed Mr. John R. Freeman, of Providence, R.I., their consulting engineer for this work.

Mr. Freeman made a careful study and personal examination of the site and, after several conferences with Mr. G. R. G. Conway, chief engineer of the Vancouver Power Company, Mr. J. W. B. Blackman, city engineer of New Westminster, and the engineers of the department, a satisfactory design was evolved, and approved by the department in February, 1912.

The plans called for a dam of the hydraulic fill type, having a maximum height of 98 feet, crest 850 feet long and 40 feet wide, upstream slope 5 to 1 and downstream slope 2, 3 and 4 to 1; total volume, 544,000 cubic yards, consisting of 117,000 cubic

yards of rock toes and 427,000 cubic yards hydraulic fill; this dam would raise the lake level to elevation 503·0, or 60 feet above the old timber crib dam, and give an additional storage of about 163,000 acre feet.

For the New Westminster water supply, a massive intake tower of concrete, situated 1,000 feet upstream from the dam, and a tunnel 1,932 feet long through rock to the east of the dam site were shown on the plans; this work is now completed, the water being turned into the city mains on July 2, 1912.

In order to carry the overflow from the lake during the construction a sluice tunnel through the rock outcrop at the east end of the dam, 501 feet long with a sectional area of 406 square feet, control tower of concrete with all necessary gates, &c., approach and outlet canals were shown on the plans; this work was all completed on May 31, 1912.

The rock outcrop at the east end of the dam was chosen for the site of the spillway, which is to be 250 feet wide, 15 feet below the crest of the dam and all in solid rock, necessitating a total excavation of 74,000 cubic yards, of which 68,000 cubic yards has been completed.

On Friday, August 30, 1912, Mr. J. B. Challies made his official visit to the works, in company with Mr. Conway. Mr. Freeman paid his fifth visit of inspection to the work on September 6, 1912, and in accordance with recommendations he then made, before hydraulic filling was commenced for the dam, a strip along the centre line, 250 feet wide was thoroughly cleaned off to the rock floor stratum, which composes the centre and west side of the dam site, the east being the rock outcrop previously mentioned; this cleaning was done by means of hydraulic sluicing, a very fine job being done,—this work was completed on October 6, 1913.

Hydraulic filling for the dam was commenced on October 7, 1912, and has been continued steadily ever since, 310,000 cubic yards or 73 per cent of the total, being now deposited and the dam built up to within 29 feet of completion.

In order to preserve the purity of the water supply of the city of New Westminster, Mr. Freeman recommended that all trees, shrubs and underbrush be cut close to the level of the ground and removed from all land to be flooded when the lake level is raised; this work was carried on until October 28, 1912, when it was closed down for the winter, 580 acres, or 67 per cent being then completed and 63 acres, or 7 per cent partly done; in connection with this work very strict sanitary regulations have been enforced, all human and camp wastes being collected and burned in incinerators, and every precaution taken to prevent any contamination of the city's water supply.

The mayor, city engineer and other officials of the city of New Westminster have paid numerous visits to the work and have always expressed themselves as being well satisfied with the prevailing conditions.

The work has been carried out by Mr. G. R. G. Conway, chief engineer of the Vancouver Power Company, with Mr. F. Ramsaur, engineer-in-charge resident on the work, Mr. John R. Freeman being the consulting engineer for the department, the undersigned acting as resident engineer for the department. Mr. A. T. Milner has acted as assistant since January, 1912, and it is with great satisfaction that I take this opportunity of acknowledging the excellence of his services.

I have the honour to be, Sir,
Your obedient servant,

R. S. STRONACH,
Resident Inspecting Engineer.

No. 9.

REPORT OF E. B. PATTERSON.

PRINCE ALBERT, SASK., March 31, 1913.

J. B. CHALLIES, Esq., C.E.,
Superintendent, Water-power Branch,
Ottawa.

SIR,—I have the honour to submit a report of the La Colle Falls hydro-electric development for the year ending March 31, 1913. (See also Plates 29 to 31.)

Early in 1909 the City Council of Prince Albert applied to this department for the water-power rights at La Colle falls on the North Saskatchewan river, and requested that a reservation be placed on all Dominion lands necessary for its development.

When all the necessary information had been placed before the department, and other essential preliminaries disposed of, an agreement under the water-power regulations was entered into on September 1, 1912, and in December of the same year the undersigned was instructed to proceed to the site as resident inspecting engineer.

The agreement calls for an initial development of 3,400 horse-power, which is to be increased from time to time up to 12,000 horse-power at the discretion of the Minister.

Hydro-electric power for Prince Albert was first discussed in 1906. In that year, C. H. Mitchell, Esq., C.E., of Toronto, was retained to investigate the water-power possibilities of Shell river. The report on this scheme showed that the minimum flow would give a small amount of power and that the cost would be excessive.

In the same year, Willis Chipman, Esq., C.E., of Toronto, who installed the water supply and sewage systems for Prince Albert, visited La Colle falls and gave it as his opinion that a power development was feasible.

In 1909, Mr. Mitchell was again called in by the city to investigate the water-power possibilities of La Colle falls. In his report a plan of development was outlined and recommended. In the fall of 1910, Mr. Mitchell was instructed to prepare plans and specifications and to that end an accurate survey was made forthwith.

In July, 1911, the late C. B. Smith, Esq., C.E., was retained as a consulting engineer. Under his direction, borings were made in the river bed. For several months borings were taken, latterly under the direction of Mr. Mitchell, and the position of the dam located.

In April, 1912, the contract for the construction of the dam, lock and headworks was let to the Ambursen Hydraulic Construction Company of Canada.

In July, 1912, Mr. Ischam Randolph, of Chicago, was retained as consulting engineer. After visiting the site he recommended the adoption of the plan of development.

At the beginning of the present year, F. A. Creighton, Esq., C.E., who has been in close touch with the work since its inception, was appointed general manager by the city of Prince Albert of the municipal hydro-electric works.

Progress of Construction.

In the spring of 1912 the contracting firm for the dam, lock and headworks began preliminary operations, building camps, cutting cordwood, clearing and setting up the plant.

In November, 1912, the first coffer dam, which encloses the lock site and about 300 feet of the dam site, was completed. Trouble, however, was experienced, and it was not till January, 1913, that the coffer dam unwatered the site. Since then no difficulty has been experienced in keeping the site dry.

Very little excavation for the lock was accomplished before September, 1912; during the winter the excavation of the frozen clay was both tedious and costly; by March 31, 16,855 cubic yards were removed.

During the month of February, 1913, excavation for the dam was begun, and by March 31, 3,741 cubic yards were excavated. The portion of the foundation uncovered showed a uniform hard impermeable clay.

Gravel for concrete is obtained in the excavation for the tailrace; excavation for gravel began in January, 1913, the frozen ground was blasted and excavation carried on with an orange peel excavator. By March 31, 4,800 cubic yards were removed.

In the latter part of February, 1913, the first concrete was placed in the land side upper entrance wall, and by March 31 the greater part of this wall was completed, also a portion of the south wall of the lock; in all, 1,416·9 cubic yards of concrete were placed to March 31. Both of these are gravity walls and were protected from freezing, after the foundations were thawed, by the use of steam pipes under canvas. The aggregate and water were also heated.

I have the honour to be, Sir,
Your obedient servant,

E. B. PATTERSON,
Resident Inspecting Engineer.

No. 10.

REPORT OF C. H. MITCHELL, ESQ., CONSULTING ENGINEER.

REPORT, CASCADE RIVER POWER DEVELOPMENT, ROCKY MOUNTAINS PARK, ALBERTA.

November 5, 1912.

J. B. Challies, Esq.,
Superintendent, Water-power Branch,
Ottawa.

Sir,—In compliance with your request and our correspondence of February last, I have to make the following report upon the project for a hydro-electric power development on the Cascade river at the outlet of lake Minnewanka, in the Rocky Mountains Park of Canada:—

PURPOSE.

The purpose of this report is to present our conclusions and recommendations as to the feasibility and commercial economic development of a hydro-electric power project capable of supplying power over a transmission line to the town of Banff to enable the Dominion Government, through its Dominion Parks Branch, to suitably supply the town with the usual public utilities, more especially light and transportation.

DATA AND INVESTIGATIONS.

I have on several visits during the months of April and July last personally examined the site and investigated the various conditions and features of the river

affecting the proposed development, and have also made a study of the requirements of the town of Banff with respect to electric lighting, etc., with a view to the employment of the hydro-electric power for that purpose.

The surveys and topographical data upon which this report is based are obtained from your field engineer (outside service) of which Mr. M. C. Hendry, B.A.Sc., is in charge in this locality; the actual surveys were carried out by Mr. K. H. Smith. Various data regarding the town of Banff and the park were furnished me under the direction of Mr. J. B. Harkin, the Superintendent of Dominion Parks.

GENERAL.

The Cascade river where flowing through the canyon in which it is proposed to develop the power is immediately below the confluence of Devil's creek, which empties from lake Minnewanka. The total area drained by these rivers is about 213 square miles, and lies wholly within the Rocky mountains; much of the water originates in mountain lakes and some in glaciers. Lake Minnewanka has an arrea of about 14 square miles, and has, during the present year, been converted into a storage reservoir for power purposes, as described below, to improve the power facilities of the Bow river in its power-producing reaches in the foot-hills of the mountains.

The power site is about 7 miles from the town of Banff by a road which is on a direct route and well travelled and maintained. The nearest railway point is at Bankhead coal mines, three miles down from the site. The small town site, one mile above on the shore of lake Minnewanka, is likely to become almost entirely a summer place; the village of Bankhead has a mining population of permanent character serving the mines.

WATER SUPPLY AND RIGHTS.

The power site and all the other portions of the project lie wholly within the Rocky Mountains Park and thus all water privileges, lands and rights of way are secured for the undertaking, the title being in the Crown through the Department of the Interior.

The natural water supply has been very much improved by regulating works which have been constructed just below the confluence of the Cascade river and Devil's creek by the Calgary Power Company, Limited, under the supervision of the Department of the Interior. Primarily, these works, as previously indicated, are for increasing the water supply, especially in the winter months, to the Calgary Power Company's power plant at Horseshoe falls on the Bow river, about 35 miles distant by river.

It is contemplated, however, in the agreement entered into by the Minister of the Interior and the Power Company that this water so stored on lake Minnewanka will be used jointly by the Calgary Power Company and the various other power users on the Bow river which may be established under future agreements with the department, and the Minister consequently has the right under the existing agreement with the Calgary Power Company, dated March 1, 1912, to control the operation of the dam as provided in clause 8 of the agreement, viz.:—

> 'The company shall, after the completion of the dam, maintain and operate the same to the satisfaction of the Minister.

As to the actual water supply available for power purposes the department has taken advantage of the construction of the storage dam to secure therefrom a continuous supply of water as provided for in clause 17 (*d*) of the agreement, viz.:—

> 'The company shall, if required, by the Minister, allow a minimum amount of water of 150 cubic feet per second to pass through the dam, which the government may use for such power purposes within the Rocky Mountains Park and

the release of such water through the dam shall, at all times, be under the full control of the Minister, or person or persons duly authorized by him for that purpose.'

There is consequently assured to the government for the purposes of power operation a minimum of 150 cubic feet per second of water throughout the year. At those seasons of the year when the river is naturally in flood, viz.: May, June, July and August the dam would be impounding water, but it is expected that the lake reservoir would be full to its allowable height, usually by July 15 at the latest; after that date there would be water wasted over the spillways of the dam, gradually diminishing in quantity to the end of the summer. It is to be expected, therefore, that during July and August there would always be an amount of water greater than 150 second feet available for power, which otherwise could not be stored. The months of July and August are the two months of greatest use for power within the park on account of the tourist season, and consequently this water supply arrangement is most advantageous to the Rocky Mountains Park.

On this account, while the available water supply has been considered to be a minimum of 150 second feet, it is contemplated in the development as laid out herein to provide for utilizing up to 200 second feet at times of peak requirements.

POWER OBTAINABLE.

The storage dam now built, as described above, has been arranged at the instance of the department so as to provide a headworks dam and intake for securing the water for power purposes. By this means a dam is already available, charged to an account other than this power project, which provides about half the total head of water contemplated in the development; the other half is in the natural fall of the river itself in the intervening distance between the dam and power station sites.

The nature of the dam being primarily for storage provides for the necessary fluctuation of lake Minnewanka levels. This fluctuation, while varying the head available for power purposes, does not unfavourably affect the power to be obtained when considering the commercial side of the undertaking, because the low-water level, and consequently the low working head will occur in the winter and spring periods when the demand for power is less than at midsummer. On the other hand, when the demand will be at a maximum for this plant in the tourist season, say during July and August, the storage basin will be filled to its maximum, and the head, and consequently the power, to be obtained will be at a maximum. As both the head obtainable and the amount of water available will both be at a maximum in July and August when most needed, the obvious type and design is one which would have a capacity utilizing the maximum head and 200 cubic feet of water per second.

The gross head of the development as outlined herein, with the storage basin filled to its highest level, is about 64 feet, of which we compute 60 feet may be taken as the effective head on the turbines. Under these conditions, at least 900 horsepower can be obtained in electrical output at the power station as a maximum capacity such as might be required at 'peak load' periods. This power, after transmission to Banff, will be reduced to about 825 horse-power net, ready for delivery to the consumers.

In order to secure this capacity of plant it is proposed to at first construct all the general works, including the power station, to the full ultimate capacity. As, however, it is anticipated that this total amount of power will not be required in Banff in the early stages of the undertaking, it is proposed herein to place power equipment in the power station for only half of the above capacity—that is, to install only one of the two power units at present.

METHOD OF DEVELOPMENT.

Dam.

The head dam, already constructed, is at the head of the rocky canyon and is a solid concrete structure, having facilities for discharging water either over its crest through stoplog spillways or through a low level in a sluiceway closed by a gate valve.

At the instance of the Department of the Interior the dam is also provided with an intake stoplog opening and a forebay into which a steel penstock thimble, 5 feet in diameter, is inserted ready for connecting in the future to a penstock or flume to lead the water to the power station. The necessary works for the development of power as outlined herein commence, therefore, at the outer end of this thimble which is already in place. The intake and penstock are set at a sufficiently low level to accommodate any level of water between the limits in which the storage basin will fluctuate.

It is to be noted that with the drawing down of the water above the dam the head will be reduced, but this will occur at a season when the demand for power will not be great.

Penstock and Flume.

It is proposed to lead a 5-foot steel pipe from the present thimble along the cliff a short distance and then enter a tunnel cut in the rock on the south side of the river of a section 7 feet by 7 feet, which would emerge at the lower end of the canyon. It is not anticipated that this tunnel will need to be lined except in the bottom and sides to offer a smooth course for the water flow.

The penstock is proposed to span the canyon as a 6-foot diameter steel pipe, supporting itself at a height about 15 feet above the water. From this point it is proposed to carry the penstock down the north bank as a wooden stave flume 6-foot diameter under pressure and set in a partial excavation; at one point this will require to be supported for about 150 feet on concrete piers. At the lower end the flume would be buried beneath the station yard.

The lower end of the flume would consist of steel 8-foot diameter and would have two 48-inch steel feed pipes fitted with valves leading to the two power units in the power station. This section would terminate in a bend curving up the hill connected to a reinforced concrete regulating tank about 12 feet diameter and say 24 feet high, or a sufficient height above the highest level of lake Minnewanka to prevent spilling, and at the same time to afford the adequate hydraulic regulation for the lower end of a long pipe such as this would be. The regulating tank should be housed in by a light wooden structure.

Power Station.

This station is proposed to be of either concrete or brick set on concrete foundations built entirely fireproof and adapted to continuous operation at all seasons. It is necessary to construct a river wall on the outside of the station, the lower to protect the tail-race and the upper to afford a station yard and protection from any high water in the river. Access to the station would be by roadway leading down from the Banff road.

It will be necessary to provide a residence nearby for housing the operating staff; this may be of wood.

Power Equipment.

It is proposed to ultimately install two power units each consisting of a 500 horse-power turbine and a 300-k.w. electric generator, together with an exciter unit separ-

ately driven. In the initial development it is proposed to install only one power unit and the exciter unit capable of generating half the total output of the station; the building being large enough for the second unit it can be installed at any time in the future when conditions of market warrant.

It is proposed to generate and transmit direct without the use of step-up transformers. All switching and subsidiary equipment would be installed as required.

Transmission Line.

It is proposed to either construct a new transmission line throughout on wooden poles and of sufficient capacity to transmit 900 horse-power to Banff or to utilize the existing line, so far as it goes, now owned and operated by the Canadian Pacific Railway Company in connection with its steam electric plant at the Bankhead coal mines, if the line can be purchased from the company. Should the latter course be adopted it will be necessary to replace the existing copper wires with larger ones if 400 horse-power or more is required to be conveyed in the initial stages. We recommend the purchase and replacement, as the line is in good condition, and have based our estimates on such a course.

Should a new line be constructed it would follow the present course and be of the same character, but larger capacity.

RECEIVING STATION AND DISTRIBUTING SYSTEM.

It is proposed to utilize the present receiving station and distributing station and equipment within the town of Banff if it can be acquired at a reasonable price from the owners, Canadian Pacific railway. This system is in excellent condition and is usable with modifications in any extended system of distribution and lighting in the town. As it is proposed in connection with the new system of lighting contemplated in the town and vicinity to extend the distribution system very considerably, it will be necessary to construct several miles of new lines, the wire for which can be secured from the transmission line.

LIGHTING SYSTEM.

In order to carry out a suitably extensive project of lighting the town and vicinity in an attractive manner, utilizing the most up-to-date types and arrangement, it will be necessary to rearrange the present system and to extend it in three principal directions, viz.: to (1) the Cave and Basin, (2) the Canadian Pacific railway hotel, and (3) the Hot Springs.

In carrying out this project it is proposed to arrange 5-lamp clusters on ornamental iron posts leading from the Canadian Pacific railway station via Lynx and Cariboo streets to Banff avenue, the main street, which it is proposed to light in the same manner throughout between Elk street and the Sanatorium hotel, but with posts closer together, say 100 feet apart on both sides of the street. It is also proposed to carry a few such lamps up toward the case and basin and to put a group opposite the latter as well as at the Canadian Pacific railway station yard. In all, sixty such 5-lamp clusters are proposed to be installed in the system herein outlined which will be fed by cables carried in underground conduits.

For the remainder of the lighting it is proposed to change over from the present system to bracket lamps on the poles themselves. On the older streets on which lines already exist this is very simple except when lines are in alleyways, in which case it is proposed to lead wires out to posts set in the centres of the blocks as shown on the accompanying plans; the number of these in the block could, of course, be increased as desired. For new lines it is proposed to carry bracket lamps as shown to Cave and Basin, Hot Springs and Canadian Pacific railway hotel.

The character of these lamps and the system of lighting would form a complete street illuminating system of the most pleasing and efficient type comparable with the best results in the cities foremost in lighting problems. The cluster lamps on the main routes would permit of underground wiring making it possible by the burying of the telephone system wiring to clear these streets of all overhead wires.

The street lamps would be on separately controlled circuits which might be operated from any one point in the town, say, the sub-station or the superintendent's office.

A plan accompanying this report shows the proposed general locations of the lighting units on the street.

POWER SUPPLY AND DISTRIBUTION.

The capacity of the power and transmission system outlined in the foregoing as an initial system, viz., say 425 horse-power laid down in Banff is amply sufficient for some time to come for all the lighting that may be desired, and at the same time will provide power for those various small uses such as motors in bakeries, laundries, printing offices, butcher shops, small machine shops and mills, etc. If, however, any customer or group of customers requiring units larger than say 10 or 20 horse-power should demand service, or if, as has been suggested, an electric railway be constructed, it will be necessary to install the second unit in the power station. In this connection it is to be borne in mind that perhaps the insurance of continuous power without fear of interruption may dictate the early installation of the second unit, but that is a matter of policy to determine later and according to the lighting or power market demands, and the extent to which the Government may wish to go in its policy of public utilities for the town and park generally.

ESTIMATES OF COST.

In the following, estimates of cost of construction are based entirely upon the construction of a new system complete from the dam (already built) to, and inclusive of, the distribution and lighting system outlined, as it is only on such a basis that the comparative costs can be readily considered.

The following estimates are based upon the current prices for labour, apparatus and supplies provided and delivered at the location required. If construction is undertaken under conditions whereby these current prices are visibly exceeded, the estimates herein given must be correspondingly increased.

The following estimate is for general works for the whole ultimate plant, but with hydraulic and electric machinery installed only sufficient to deliver 425 horse-power in Banff:—

1. Penstock and flume, including headworks connections, tunnel, river span wood flume, feeder section and rising section complete ready for water	$22,500 00
Note.—Should it be thought desirable in order to secure scenic effect, the river crossing section could be depressed and the pipe laid across on the bed of river the river passing over top of it; cost about $4,000 extra.	
2. Regulating tank, including housing	1,500 00
3. Power station; foundations and buildings complete with interior work and fittings	9,800 00
4. Staff house and miscellaneous	3,000 00
5. Equipment in power station, consisting of hydraulic and electric equipment sufficient to deliver 425 horse-power in Banff, together with all subsidiary machinery such as governors, switching, piping, fittings, &c	15,200 00
Note.—A second unit when required could be installed for about $15,000 additional, after which the plant could deliver 825 horse-power net in Banff.	

6. Transmission line complete, total length about 7¼ miles, capable of transmitting 900 horse-power	8 500 00
7. Distributing system in and around Banff, comprising receiving station and shop, step-down transformers, town wiring, street fixtures and transformers, the whole leading up to all lighting connections but no lighting	10,000 00
8. New street lighting system complete, including 60 five-cluster lamp sets and posts, and 250 bracket lamps on poles, together with underground wiring for clusters	9,000 00
Total	$79,500 00
Add for contingencies, engineering supervision and inspection, 12 per cent say	9,500 00
Grand total	$89,000 00

CONTRA.

If the five miles of existing transmission line from Bankhead mines to Banff, and the town receiving station and equipment, the existing distribution system and connections to private consumers' buildings, etc., and the existing street lighting (consisting of 25 lamps) be acquired by the Government from the C. P. R. Company, the foregoing grand total may be reduced by about $3,000, which we estimate as the probable saving in value of this equipment over the proposed plant as outlined herein. This is based upon a valuation of the portion of the C. P. R. plant (physical assets only) which we can utilize, which we place at $8,000 to $10,000, but these figures are rough and for estimating purposes only, and the correct present day valuation can only be determined by a more exact investigation than I have been enabled to make. These figures ($8,000 to $10,000) represent the value to the Government of the physical assets in the existing system and do not take into consideration any franchise or business asset, as the company has no franchise on the streets; it has, however, a commercial business worked up in the town whereby private consumers are supplied.

Net grand total, utilizing present plant, $86,000.

REVENUE AND COST OF OPERATION.

Annual Revenue.

The revenue derived by the Canadian Pacific Railway Company from the operation of its present plant within the town of Banff during the year 1911 from both the street lighting (town) and private consumers of light is stated to be about $11,000. Of this we estimate, based on figures given for street lighting rates, that about $1,500 is for street lighting, and the remainder for private lighting. These amounts would still be derived from the new plant with the probable prospect, however, that as the system gets larger and more comprehensive, the rate to private consumers might be reduced so as to give the residents the benefit of the government's operation at rates only slightly over cost.

Under the new proposed system of lighting there would be a larger revenue derivable and chargeable to street lighting, and this we would base on such figures (viz., at $40 per 12-month year for 5-lamp clusters and $10 per 12-month year for single bracket lamps) as would produce a revenue of $3,000 per year after making due allowance for a considerable reduction, as at present, in the number of street lamps operated during the five winter months. This practically means that the Government would pay, say, $1,500 per year more for the new proposed lighting of the streets than it is paying now with the present system.

On the other hand the private lighting will undoubtedly increase and must increase in the natural course of events of natural expansion, and consequent upon the extended area of the system. It is reasonable to assume that within say two

years time (say by the time the new plant is well in operation) this growth would amount to an increase of at least 25 per cent over and above the present revenue for private lighting alone, or, in other words, could be expected to amount to about $12,000, assuming the same prices were retained.

The total annual revenue therefore to be expected say two years hence can be reasonably set down at $15,000. The revenue in the future, with possible power and street railway included, is difficult to conjecture at present, but would involve only slightly greater cost of operation.

Annual Cost of Operation.

In order to place this project on a financial basis in the same manner as if it was a private corporation doing business as a lighting and power company, and be able to make a comparison with other going concerns of the same character the following is presented:—

Assume that (as if for a private company) the funds for the construction and installation of these works were raised by a debenture issue say of $90,000 at 5 per cent to be retired in 30 years, and that the principal and interest is repaid in thirty equal annual instalments. The annual costs of operation and maintenance of the plant throughout will be approximately as follows:—

I. Overhead charges—		
1. Yearly instalment of principal and interest, based on foregoing..	$ 5,850 00	
2. Maintenance account, being an amount set aside yearly against major repairs, renewals and reasonable extensions, 2½ per cent..	2,250 00	
		$ 8,100 00
II. Operation charges—		
1. Salary, superintendent and general office expenses (within Park office)..	$ 2,000 00	
2. Wages of operators at power station.. ..	2,200 00	
3. Supplies and minor repairs chargeable to income..	900 00	
		$ 5,100 00
Total annual cost..		$ 13,200 00

If the foregoing annual cost of operation and maintenance is placed against the total amount of power capable of being delivered by the plant in Banff, viz., 425 horse-power, small though it is and though the only output from the initial installation the annual cost per horse-power (24 hours per day) laid down in Banff is approximately $31.

It is to be noted that steam generated electric power laid down in Banff in the same manner as hydro-electric, using the usual types of engine under ordinary economic commercial conditions would on the same basis, in our opinion, cost not less than $50 per horse-power per year, even with cheap coal near by.

Yours very truly,

C. H. MITCHELL,

M. Can. Soc. C.E.

M. Am. Soc. C.E.

NOTE.—Since the submission of the foregoing report (November 5, 1912) the proposed power project has been considerably enlarged in its character and purpose. It

is proposed to use more water at times of peak loads under special arrangements for utilizing the surplus quantity in flood (summer periods), and thus obtain more power. This output we place at 1,000 horse-power in electrical energy under normal conditions delivered in Banff. We propose to provide equipment capacity in the ultimate power station for 1,800 horse-power with a hydraulic plant of three units, of which two units would be in the initial station aggregating 1,200 horse-power, producing 1,000 horse-power in Banff ready for consumers. The water conduits (tunnel, flume, regulating tank and feeder section) are on this account larger than originally contemplated, and the same is true of the power station which in the initial development will house two units instead of one. On the electrical side the transmission line, receiving station in Banff and the distribution system are of correspondingly greater capacity and larger scope. In the lighting system, while not of larger capacity in the initial stage, provisions have been made for considerably more aesthetic features.

The estimated cost of the foregoing entire project, considered as an initial development, we place at $138,000. This provides a capacity over twice that originally contemplated in the initial development outlined in the report of November 5, 1912.

The annual cost combined, of overhead charges, operation and maintenance, based upon the same conditions as in the original report and assuming the use of only 500 horse-power, (half the initial output), would be $37.50 per horse-power. If the whole initial output, viz., 1,000 horse-power, were considered, the annual cost would be $18.75 in both cases delivered and used in Banff, inclusive of the actual lighting itself.

C. H. M.

No. 11.

REPORT OF T. H. DUNN.

J. B. Challies, Esq., C.E.,
Superintendent, Water-power Branch,

Sir,—In carrying out your instructions dated July 4, 1912, I have made a partial examination of the Saskatchewan river between The Pas and Cross lake, and also the flooded area contiguous to the river, with a view to determining the feasibility and desirability, from an agricultural point of view, of reclaiming these lands.

In endeavouring to carry out this work several deterrent and unforeseen factors entered into the problem which were absolutely unavoidable. We were continually hampered by wet weather and high winds, the latter condition rendering the lakes unnavigable and resulting in the loss by drowning of four of our party on September 6. This sad accident caused the total suspension of all engineering work for nearly three weeks, and at the end of that time when the work was taken up again it was impossible to procure men to take the places of those who were lost. We did succeed in getting a couple of Indians for a few days at a time, but the fall hunt had commenced and the lure was too strong to be resisted by a mere Indian.

In addition to this, my instructions called for all detailed surveys to be made by a power party sent out under your instructions by Mr. D. L. McLean, chief engineer of the Manitoba Hydrographic Survey. This party was at Grand Rapids in charge of Mr. E. B. Patterson who was making a survey of the rapids for power purposes and, although good progress was made throughout the season, the power work was not completed until about October 10, which was too late to permit of any new work being started, as the last boat on which the party could return to Winnipeg was leaving Grand Rapids on October 15.

The absence of these detailed surveys and the extreme shortness of the working season for the reasons mentioned makes it impossible for me to give definite answers to the questions propounded in your instructions.

Taking up these problems in the order in which they appear in your instructions, I will endeavour to give such a solution as would seem to be indicated by the information I have been able to secure, but, in some cases, the information is too meagre and the data too uncertain to justify me in hazarding an opinion.

The first question presented in the instructions is:—

(1) Is it possible to lower Cedar lake to nearly the same elevation as Cross lake?

It is, of course, impracticable to bring these two lakes to quite the same elevation owing to the fall necessary to give the required discharge, but I do not consider this to be the problem which it is intended to present in this question.

Cedar lake has sufficient depth, except at a few points, to admit of the proposed lowering without damage to navigation.

That portion of the lake immediately adjoining the Narrows is shallow, and the excavations for the proposed canal would have to be continued about a quarter of a mile into the lake.

There is also a shoal off Rabbit point which has only three or four feet of water at certain times of the year, while near Duncan island, at the west end of the lake, there is another shoal. Any scheme to lower Cedar lake would therefore necessitate the making of a cut through these shoals.

While the extent of this work is not definitely known, it is not thought to be a serious obstruction.

(2) What will be the immediate effect of such lowering?

(*a*) What acreage will be thereby reclaimed?

(*b*) What is the value of the area so reclaimed?

If Cedar lake be lowered, as proposed, an outlet will be thereby provided for a very large area, the extent of which has never been determined by any survey. An approximate boundary was shown by Mr. William Ogilvie, D.L.S., on his map of 1911, and from this I estimate the area to be about 2,000,000 acres. This land is at present either flooded or so isolated by the flooded area as to be almost totally inaccessible.

The water from this immense area would reach Cedar lake through the medium of the Saskatchewan and Summerberry rivers and the other natural watercourses of the country.

The area actually reclaimed by the lowering of the waters of Cedar lake alone would probably not amount to more than 20 per cent of this total area, or about 400,000 acres, and would be confined to the country adjoining Cedar lake at the west end and extending to Moose lake and westward along to Summerberry river. The reclamation of the balance of the two million acres could not be accomplished simply by the lowering of the lake, but this must be followed up by improvements in the Saskatchewan river at several points, notably at a point about 3½ miles upstream from Cedar Lake Post, at the Frying Pan, near Hill Island and the Wooden Tent.

In addition to this an interior system of drainage will have to be provided for the removal of pond water and for the run-off from the precipitation of the district.

This latter problem is not included in these investigations. The soil throughout this area is practically all alluvial in origin so far as is at present known.

It is impossible to place a value on this land until more is known about the interior. No samples of the soil of the interior have ever been taken owing to the fact that the land is pretty generally covered with water. The high water prevailing during the season of 1912 made this particularly difficult and unsatisfactory. It was not possible, with the instruments at our disposal, to take soil samples where the soil was covered with water.

(3) What will be the indirect effect of such lowering on the low-lying lands contiguous to the Saskatchewan river?

(*a*) Below The Pas?

(*b*) Above The Pas?

The lowering of the lake will provide an outlet for the water from all the lands below The Pas. This outlet constitutes an indirect benefit to the flooded area between the Frying Pan and The Pas.

This area, however, while greatly relieved of its burden, would not be in a position to derive full benefit from the outlet thus provided unless some improvement were made in the river itself. Such an improvement would involve the deepening of the river at points mentioned above.

If the lowering of Cedar lake be followed up with this suggested improvement in the river, the outlet will be brought within a reasonable distance from the lands it is proposed to drain and will be accessible to any scheme of interior drainage.

The effect above The Pas would be to lower the water slightly, but this would not be appreciable during the flood period owing chiefly to the fact that the Saskatchewan river takes a rather sharp turn to the left at The Pas and is much narrower at this point and for some distance below than it is above.

In addition to this the condition of high water originates at the sources of the river and progresses toward the outlet, being caused by the melting of snow in the Rocky mountains, and, naturally, the upstream districts, if sufficiently low, will be flooded first.

The result of these two conditions is that there is a flood at The Pas about three weeks before any flood occurs at Cedar lake, and it is practically certain that any scheme of drainage which does not provide for the removal of the obstruction at The Pas could afford but little relief to the lands above The Pas.

(4) What effect will such lowering have on the Saskatchewan river proper, through the territory in question?

The lowering of Cedar lake will increase the velocity of the water in the Saskatchewan river and cause erosion of the soft materials comprising the sides and bottom of the river. At four or five places along the main river the bottom is hard and stony and will erode very slowly, if at all, as rock will be encountered at the turn, three and a half miles above Cedar Lake Post and at the Frying Pan. There is also a stony rapid in the channel known as Head river, but the Summerberry channel is free from rapids, and the sides and bottom are entirely of soft material which would erode with considerable facility. Unfortunately, however, this stream is narrow and would not accommodate, under the most favourable conditions for erosion for many years following the improvements, more than one-half of the flood discharge.

I do not anticipate any serious change in alignment of the river bed as a result of washing away the banks on the turns, as there are few, if any, turns sufficiently sharp to give rise to any serious erosion. This is a matter, however, which calls for further investigation.

(5) What effect will such lowering have on navigation throughout the area in question?

If a proper scheme of drainage be carried out, I consider the navigability of the waters will be greatly improved by the more or less uniform distribution of the fall.

Between Cedar and Cross lakes there are two rapids, viz., the Flying Post rapid and the Demi-Charge, the latter being a very heavy rapid, and not navigable. The total fall between the lakes is believed to be about 15 feet. This is Mr. Ogilvie's estimate, but no complete line of levels has been taken so far as I am aware. The construction of the proposed canal would reduce this fall to about four feet and thus remove every obstacle to navigation at this point. This, however, will render Cedar lake unnavigable at two points, and will have the effect of developing

some rather shallow and strong rapids in the Saskatchewan river between Cedar Lake Post and The Pas.

It will be necessary to deepen these points in Cedar lake, and either to deepen the Saskatchewan at the points previously mentioned or confine navigation to the Summerberry channel during low water.

This deepening of the lake and river will be necessary for drainage in any case, and when completed will be of great benefit to navigation which is somewhat difficult at certain points during low water.

The absence of the detailed surveys which are so necessary between Cedar lake and Cross lake makes it impossible to make more than a very rough approximation of the cost of the work.

To construct a canal 1,200 feet wide along the course C-F, laid down on the plan, which course is 25,500 feet long, would cost in the neighborhood of $5,000,000. This canal would have a capacity of about 50,000 second feet and would provide for a flood of ordinary height, but would not prevent flooding in seasons of extra high water, occurring every three or four years.

To provide for a discharge above 50,000 second feet it will be necessary to deepen the river in the vicinity of the Narrows and Flying Post rapids at an additional cost of perhaps $1,000,000. It may be found more economical to widen the upper end of the canal than to deepen the river. The cross-section of the canal must be so designed as to preserve at least six feet of water during low-water periods for purposes of navigation. As there is no survey on which to base this estimate, it must be considered as a very rough approximation.

No estimate of the cost of the work in Cedar lake and the river west of Cedar lake can be given at present.

To determine even approximately the cost of carrying out this scheme would require nothing less than the programme laid down in your 1912 instructions, and I cannot do better than recommend the continuance of the work along the lines cited therein.

It is desirable, however, that one important addition be made to this programme, and I strongly recommend that a survey and profile be made of the Saskatchewan river between Cedar lake and The Pas, together with cross-sections at all the rapids and an approximate classification of the materials likely to be excavated.

A more serious effort than anything heretofore undertaken must be made in order to determine the value and extent of the lands which it is sought to reclaim.

Regarding the reported rapid in Moose Lake creek near Moose lake I beg to report that an examination discloses the fact that no such rapid exists. No surveys will therefore be required at this point. There is, however, a shallow place in Moose lake at the mouth of the creek which will be discussed further on in my report.

A scheme so extensive as the one under consideration, and involving the expenditure of such a large sum of money, should not be undertaken without the fullest investigation. That such an investigation is desirable and justifiable on economic grounds is strongly supported by all the information so far obtained.

I therefore recommend that this work be proceeded with as outlined in your instructions and with the additions above mentioned as soon as navigation opens in the spring.

The attached report of my investigations is respectfully submitted.

I have the honour to be, Sir,

Your obedient servant,

THOS. H. DUNN, O.L.S., C.E.

Engineer in Charge of P.R.P.

Dated at Ottawa, this 7th day of March, 1913.

Itinerary.

On receiving my instructions of July 4, 1912, I immediately began preparations for the work and reported in Ottawa on July 6.

From this date until July 12 I was busy arranging for the necessary instruments and getting together such articles as would be required on the trip.

I arrived in Winnipeg on the evening of July 15, where I was detained until July 29, waiting for my instruments to arrive from Ottawa. This time was profitably spent in the purchase of supplies and camp outfit and in the very difficult business of hiring men. I found it impossible to get experienced men, so had to take the best who presented themselves in answer to my advertisement.

Considerable pains were taken to explain to the men the difficulties and dangers of the work they were expected to perform, and as they were for the most part inexperienced I was particularly careful not to bring any undue influence to bear on them to induce them to join the party, but rather the contrary.

Mr. O. W. N. Charlton, who was to act as my assistant, arrived from Toronto on July 28, and on the morning of the 29th we left for The Pas, with five men and the cook, one man of our party having failed to turn up.

We arrived in The Pas on July 30 and, while waiting for information from the Surveyor General's Department and also for some parts of my transit which had not yet arrived from Ottawa, I made a trip up to the forks of the Pasquia river. This was done for the purpose of keeping the men together and because it was believed to be cheaper than staying at The Pas.

In ascending the Pasquia river we observed the same strange phenomenon mentioned by the late Mr. Ogilvie in his 1911 report. Instead of the Pasquia emptying into the Saskatchewan as it does under normal conditions, the Saskatchewan was emptying its waters into the Pasquia, resulting in a strong current 'upstream' in the latter river. This proved of great assistance to us going up but not so on the return journey.

We left The Pas on August 3 and returned on August 12, experiencing on this latter date the worst wind and rain storm of the season. So delayed were we by this storm that we did not reach The Pas until nine o'clock at night and were thoroughly drenched and shivering in the cold north wind.

We made an approximate survey of a portion of the Pasquia river but, owing to the fierceness of the storm, we could not connect it across the lake, barely succeeding in saving our canoes from swamping.

On our arrival at The Pas we found information for which we had been waiting had arrived, so after drying our clothes and provisions and attending to correspondence, we divided our provisions into two parts, one of which we stored at The Pas, and the other we loaded into our canoes and, on August 15, started down the Saskatchewan river on our way to Cross lake. We took no soundings on the way down, as we were anxious to reach Cross lake before the Power party at Grand rapids completed their power survey, and also because the water was so high that it was slow and difficult work taking soundings. The shoals which were plainly visible at ordinary or low water could not be located without great labour. A short distance below The Pas I found the banks of the Saskatchewan were only a few feet above the water and very narrow, while lower down the river was overflowing its banks in many places and the water rushing away in great volumes into the innumerable swamps and shallow lakes which comprise the interior. At this time there was no chance of getting soil samples except along the banks of the stream, which would be of little value in determining the quality of the soil in the interior.

Approaching Cedar lake we found a perfect maze of channels branching off from the main Saskatchewan, and each carrying its burden of waters by its own chosen route towards Cedar lake. Some of these channels are larger than the one we were follow-

ing, which is the boat channel. There are short cuts in same places for the initiated, but we kept to the main channel.

We arrived at Cedar Lake Post on August 17, where we were kindly received by Mr. Duff, the factor for the Hudson's Bay Company, and Mr. Fraser, who was in charge of the Anglican Mission at The Pas but acting temporarily in that capacity at Cedar Lake Mission.

The Indian settlement on the reserve here is called Chemawawin, which is 'The place of drawing the seine.' It has been called by Dr. Klotz and Mr. Ogilvie, Chemihawin, but those who know the Cree language well say that this is not correct. The Indians generally slur the word and call it 'Chemihawn.'

Whatever may have been its reputation in the past it is rather a poor fishing ground at present, except for jackfish. It is necessary to go to Cedar lake for whitefish and sturgeon.

Arriving at Cedar Lake Post on Saturday we remained over Sunday, and on Monday 19 we engaged two Indians to take us to Cross lake. We had considerable difficulty in getting Indians to accompany us, as any kind of real work does not appeal to them very strongly. We found only two on the reserve who were willing to go and these would only promise to stay one week and that on the condition that they receive $2.50 per day each instead of the regular $1.25 per day regularly paid by the Hudson's Bay Company at this post. After taking some observations for latitude at Cedar Lake Post and resting over Sunday we left on Monday, August 19, for Cross lake.

Owing to the prevalence of high winds on Cedar lake much time was lost as it was impossible to cross the lake except under the most favourable conditions. We finally arrived at Cross lake on the evening of August 22 and made camp at the mouth of the river on the north bank.

On August 23, after attending to correspondence, I left Mr. Charlton in charge of the camp with instructions to begin work at once and, taking the two Indians, I started for Grand Rapids, where I arrived the same evening. Here I found Mr. Patterson in charge of Mr. McLean's power party, and learned from him that it would be near the close of the season before the power survey would be completed, and that I could not expect much assistance from that quarter in making my detailed surveys. I therefore returned to my camp at Cross lake on August 24, where I found that work had been commenced on the Cross Lake survey according to my instructions. Immediately upon my return from Grand Rapids the Indian guides prepared to leave for Cedar Lake Post. They had hired on the condition that they should be at liberty to return home upon our arrival at Cross lake on the return trip and this was the only basis on which they would consent to go. I now endeavoured to get them to remain during the balance of the season but they refused absolutely.

In view of the fact that Mr. McLean's survey party in charge of Mr. E. B. Patterson, at Grand Rapids, would not be through with their work in time to make my surveys for me, I decided to undertake a part, at least, of this work myself.

Owing, however, to continued bad weather with very high winds which prevented us from going on the lake with canoes, I had to abandon this idea of attempting work for which we had not outfitted. While encamped at Cross lake I established a meridian by observations on Polaris and extended the line one and a half miles north for the purpose of examining the interior. I also determined the latitude and longitude as nearly as possible with the instruments at my disposal.

Whenever the weather permitted we examined the shores of Cross lake and explored the little known portion of its northern extension, at the same time making a rough survey of the northwest shore. It was while engaged in this work on September 6, that four labourers of my party were lost through drowning. In this connection I wish to say that the two Peterborough canoes used by my party were new and of large size and good model. They had not been damaged in any way and did not leak. I also had one very much smaller chestnut canoe which I used myself and this

latter canoe was used by my assistant, Mr. Charlton, and the rodman, Mr. Merritt, on the fateful day, while the four men who were drowned were in one of the large Peterboroughs. There was no freight in the large canoe except four axes and a levelling rod, all of which lay in the bottom of the canoe. The following statement furnished to the Royal North West Mounted Police gives the details of what took place after leaving camp:—

CROSS LAKE, MAN., September 21, 1912.

Statement of O. W. N. Charlton, Assistant Engineer to Thos. H. Dunn, C.E., Engineer In charge P. R. P., W. P. Branch, Department Interior, Ottawa.

'I hereby state:—

'That on Friday September 6, 1912, I, O. W. N. Charlton, was out in Cross lake in canoe in company with Arthur Merritt, rodman of our party, and behind me in larger canoe were four men of our party, known as Fred McLennan, Hugh W. Cochrane, George A. White and William McMullen (chainman and axeman); these four had instructions from me to follow my canoe and keep close in shore. On reaching northeast corner from camp, the lake which had been rough became worse and high wind started. I then observed that the four men as named above in canoe were acting on their own initiative and endeavouring to make shore of island to east of mainland, evidently to obtain protection from wind. A few minutes later on looking round I could plainly see that members of the late party were placing their weight on side of canoe to open to wind thereby exposing their craft to great danger. I endeavoured to turn, but could not do so on account of heavy seas, at same time shipping considerable water in my own canoe. At this time the two canoes were widely separated, the larger one evidently having weathered the gale. A short time later the party were seen paddling parallel to shore apparently O.K. This was last sight of party. My canoe was blown about two miles down lake, and I beached it as soon as possible.

'The seas by now were extremely heavy and wind very strong. I immediately took my transit from case and swept shore lines for sight of party. I was unable to locate them at this time and thought that they had reached shore. We were forced to remain on point from 10.30 a.m. until 3 p.m. when wind changed and during lull I returned to main camp. Mr. Dunn and myself leaving immediately to search for party, but found no trace.

'On September 15, after nine days' search three bodies were recovered in lake, death evidently being due to drowning. These bodies were interred at Mission cemetery (Anglican) at Grand Rapids.

'On September 18 the police boat, in charge of Corporal Grennan, arrived from Le Pas at 3 p.m. and search was continued.

'On Friday, September 20, 1912, at 8 a.m. the body of the late William McMullen was recovered near point where last seen on day of accident. The body was interred on Saturday, September 21, on island, the body being interred here on account of emaciated condition.

'All bodies on recovery showed signs of accident being totally unexpected, none having disrobed, and being in their full bush kit, which made swimming very difficult.'

(Sgd.) O. W. N. CHARLTON.

'I, Arthur Merritt, rodman of the above party, hereby corroborate the above statement with the addition that when we noticed the canoes were separated we shouted to the four men to turn back, but evidently they did not hear us.'

(Sgd.) ARTHUR MERRITT.

I wish to add to the above statement that during the preceding night, and in the morning of September 6, the wind was off the west shore and while my instructions at first were that no work should be done on the lake that day I afterwards consented, on request from Mr. Charlton, to allow him to continue the work of the day before. This was in consequence of the fact that the wind had largely subsided and on the understanding that they would keep close to the west shore, where they would be protected from the wind. It seems that by the time the canoes reached a point 1¾ miles from camp the wind shifted to the southeast and increased in intensity. Just why the men in the large canoe abandoned the same course of running down the wind and attempted to cross at right angles to the wind and in a direction not necessary to reach their destination it is impossible even to guess. All the evidence points to the fact that their canoe was upset by the load being all placed on one side as mentioned in Mr. Charlton's statement.

In our search for the bodies we had every assistance possible from Mr. Patterson and party of Grand Rapids, and in interring the bodies we were treated with great kindness by Mr. Morris, the Anglican missionary at Grand Rapids, who looked after the digging of the graves and conducted the funeral service.

On Monday, September 9, we found the canoe and paddles and some clothing, and concluding that the worst had happened I immediately had drags constructed and engaged nine Indians, all I could get, and put them to work dragging the lake in the vicinity of the place where the canoe was last seen. Nothing, however, was found until the eighth day, when one body came to the surface, and on the ninth day two bodies were found floating on the water. These proved to be the bodies of Hugh W. Cochrane, George A. White and Fred. McLennan, and were buried in the Anglican cemetery at Grand Rapids in the order here named, counting from south to north, on the sixteenth day of September, 1912.

I returned to Cross lake on the 17th and, leaving Mr. Charlton in charge of the camp, started for The Pas on the 18th, with two Indians who had that day arrived from Cedar lake in response to a message sent in accordance with a previous arrangement. I wished to go to The Pas to confer with the Royal Northwest Mounted Police, and also to communicate with the department. I had the misfortune to miss the police on Cedar lake as Corporal Grennan's canoe went around Rabbit point while I made a portage across it.

The corporal had received an oral message which I had sent some days before with the Bishop's party and acting promptly arrived at Cross Lake camp on September 18, the same day I had left. The police, in company with Mr. Charlton, found the body of William McMullen on September 20, and buried it on Channel Island on September 21.

Owing to exceptionally fine weather on September 18 and very hard work on the part of my Indians, we made a record trip from Cross lake and reached Cedar Lake Post at 8.30 p.m. the same day. This was the last of the fine weather, however, on our trip and we had to fight every inch of the way from Cedar Lake Post to The Pas against a fierce head wind and, for the most part, in a downpour of rain.

We left Cedar Lake Post on September 19 at 2 p.m. and did not reach The Pas until 9.30 p.m. September 22. The weather was now very cold and the rain had turned to sleet.

After communicating with the department and giving a statement of the drowning accident to the police, I arranged with Mr. T. H. P. Lamb, of Moose lake, to take me down to the Narrows in his launch but, before leaving, I received a telegram from the department asking me to go to Winnipeg for a conference regarding the reclamation project.

I returned to The Pas on October 3, and, on arrival there, I found, to my great surprise, that the sole remaining labourer of my party was there to meet me. It seems he had taken ill shortly after I had left camp and had come to The Pas with the police, leaving Mr. Charlton alone with the cook to carry on the work. This

caused me great anxiety as I knew no Indians could be secured for more than a day or two at most as they were all out on the hunt and making from $4 to $20 per day by the sale of muskrat skins.

I therefore made all haste to return to camp and, after making a chain for deep-water sounding, I started down the river on October 5 in company with Mr. Lamb and my last remaining labourer, who had now completely recovered from his recent illness.

My arrangement with Mr. Lamb necessitated our going by way of Moose lake, at which point we arrived the same evening, but owing to darkness and a high north wind we could not enter the lake with our launch but had to walk along the shore to reach Mr. Lamb's home at The Post, a distance of one and a half miles westerly. This necessitated the fording of a small creek, the waters of which were somewhat swollen by the north blow.

We remained at Moose lake over Sunday comfortably housed in Mr. Lamb's fine new house. Mr. Lamb has also a good store at Moose lake, well supplied with all the necessaries and many luxuries.

On Monday, October 7, we went to Cedar Lake Post and thence to Cedar lake where we camped on an island at the west end of the lake. The wind was high and rising, and in the morning we found we could not venture on the lake so remained in camp, wind bound until the following morning.

We crossed Cedar lake on October 9, but missed Mr. Charlton's camp owing to misdirection received at Cedar Lake Post. We camped just above the Demi-Charge rapid and on the following morning went down to the old camp at Cross lake where we were informed by Indians that Mr. Charlton was in camp on the northerly shore of Cedar lake a short distance above the Narrows. We were soon at camp and just in time as they had their canoes loaded and were about to make a start to try and cross the lake and reach Chemawawin, since no further work could be done with the party reduced to one engineer and the cook.

I learned that a couple of Indians had joined the party for a time but these had left some days before my arrival.

After taking some soundings in the lake I arranged for an early departure for The Pas as my arrangement with Mr. Lamb was to last only one week from Moose lake until our return to The Pas. His business would not permit him to remain longer and, having lost our men and one canoe, we had no other way to get back except by means of the launch. We arrived at The Pas on October 14 and on 15th I paid off my one remaining man and cook. On the 16th I was fortunate enough to make arrangements with Mr. Jackson, the inspector of Indian Agencies, by which I was permitted to use the Indian Department launch *Okema* for a trip to Cedar lake, and as the water was now falling quite rapidly I hoped to be able to get some soundings in the Saskatchewan river. I therefore purchased the necessary gasoline and engaged a man to run the engine and started down the river again on October 17. We reached Cedar Lake Post on the 18th and started on the return journey on the 19th. On the 20th we encountered a blinding snow storm which prevented our travelling and interfered materially with the building of fires for we had to cook outside, although we were comfortably housed aboard at night, as the launch was full cabined.

We took soundings at several points along the river and returned to The Pas on October 23. On the 24th we stored our outfit, and on 25th we left for Winnipeg.

HISTORY AND GENERAL OUTLINE OF WORK.

In the provinces of Manitoba and Saskatchewan, between latitude 53° 10′ and 54° 10′ and longitude 100° and 103°, lies a very extensive area of drowned land. The flooding of this valuable area is caused by the overflow of the Saskatchewan river during the warm weather in the summer when the snow melts in the Rocky Mountains.

The course of the Saskatchewan is crossed near its outlet into lake Winnipeg by an extensive rocky ridge forming a very heavy rapid in the river, known as Grand rapids. This occurs at about three miles from lake Winnipeg.

About fourteen miles farther up the river there is another rocky obstruction forming the Demi-Charge rapids just at the entrance of the Saskatchewan river into Cross lake and between Cross lake and Grand rapids are two lesser rapids known as Cross Lake rapids and Red Rock rapids. Just above the Demi-Charge rapids is Flying Post rapids, which is comparatively unimportant.

These five rapids are distributed along the river between Cedar lake and lake Winnipeg, a distance of about 22 miles. In this 22 miles there is a fall of about 119 feet, or an average of 5·41 feet per mile, while from The Pas to Cedar lake, a distance of 75 miles, the fall is believed to be approximately ·32 feet per mile.

As the grades on the upper reaches of the river are very heavy it is not difficult to see what must happen to the portion of the river which lies between these heavy grades on the west and the rocky obstructions on the east.

This flooded condition has often been observed and noted by explorers, and suggestions have been made as to the possibility and desirability of reclaiming the area. It was not, however, until the year 1910 that any active attention was given to the matter. The late Mr. R. E. Young, then chief geographer of the department, urged that a reconnaissance investigation be made in the field, and the late William Ogilvie was instructed to pass through the district on his way, in the summer of 1910, to Grand rapids and the Nelson river, with a view to a preliminary examination of the possibility of draining this district or reclaiming any considerable area and, based on his recommendations to Mr. Young, he was instructed to make a special examination of the flooded area during the following summer. As a result of Mr. Ogilvie's investigations during the summer of 1911 a very interesting and instructive report and plan was filed in this department.

The very encouraging information contained in this report induced the department to continue the investigations in order to obtain more definite information concerning the engineering problems which still remained so largely a matter of opinion and conjecture. This led to the investigation which I conducted under your instructions in the season of 1912.

The plan suggested for the reclamation of this area is the construction of a canal through the rocky barrier between Cedar lake and Cross lake and thereby reducing the elevation of the surface of Cedar lake to that of Cross lake. Should this be found insufficient, it has been further suggested that the elevation of both Cross and Cedar lakes might be lowered some four or five feet by making a cut through Cross lake rapids.

The soil of the whole flooded area may be described as alluvial, forming the bottom of what was once an extensive lake which has been gradually, but not completely, drained by the slow process of erosion and breaking away of the rock barriers on this eastern margin.

In addition to this gradual wearing away of the rock barrier the more rapid action of building up the old lake bottom by the deposit of silt from the heavily charged waters of the Saskatchewan has also been going on. This deposit of silt ceases, however, as soon as the soil surface reaches the level of high water and then the work of upbuilding is taken up by the growth and decay of vegetation.

It was suggested by Mr. Forward, then an engineer in the Public Works Department, in a reconnaissance report to his department in 1909 on the navigation of the Saskatchewan river, that if the river were dammed and the drowned area flooded more deeply the deposit of silt would raise the soil surface to such a height that the removal of the dam and consequent lowering of the impounded waters would leave the land sufficiently dry for cultivation.

It is extremely doubtful if such a result would follow such action, as the deposit of silt in any considerable quantity requires periodical flooding and not continuous flooding as in a lake. The lake formed by the proposed dam would not be different from Cedar lake, which is not filling to any great extent except at the east end, and where the silt-charged waters of the Saskatchewan come in contact with the still waters of the lake. So much of the silt is deposited at and near this point that very little ever reaches the remoter portions of the lake.

Undoubtedly there is no way to reclaim this land for agricultural purposes, except by a canal between Cedar and Cross lakes. It could not be drained into lake Winnipegosis as that lake is practically on the same level as Cedar lake, and would have to be lowered before it would be available as an outlet for Saskatchewan waters. Some benefit might, in the years to come, be derived from the diversion of the upper waters for irrigation purposes, but this is not likely to be appreciable.

No argument or finding, based on observations of the action of any section of a river, more or less remote from its outlet, can avail against this proposal which contemplates the improvement of the outlet itself. The fall at the outlet of 119 feet in 22 miles takes it out of the class with the Nile, Mississippi or Danube.

It therefore remains to find the most economical route for a canal to lower Cedar lake sufficiently to relieve the drowned area of its burden of waters.

Cross Lake.

According to the traverse made by Dr. Klotz and embodied in his report in 1884, the width of Cross lake from Calico island to the point at which the river leaves the lake on the east side is 4¼ miles. The length from north to south is about 17 miles.

The northern portion of this lake is long and narrow and has several islands. It was but little known previous to 1912 as no survey had been made heretofore.

The portion south of Channel island is somewhat circular in shape, is entirely open and free from islands and of good depth. There is quite a noticeable current across the lake from the point where the Saskatchewan river debouches through the Demi Charge rapid into Cross lake, on the west side, to Cross lake rapid, where the lake discharges its waters into the river on the east side.

On Mr. Ogilvie's plan, dated June 12, 1912, the elevation of Cross lake is given at 812 feet, and in White's book of altitudes it is given at 822 feet.

Taking the elevation of lake Winnipeg at 715 feet and adding 105 feet, the difference in elevation between lake Winnipeg and Cross lake, as determined by E. B. Patterson, C.E., in 1912, we have for the elevation of Cross lake, 820 feet. The difference of 112 feet in elevation between lake Winnipeg and Cross lake, as given in White's book of altitudes, is improbable.

The latitude of Cross Lake camp at the foot of the Demi-Charge rapids is 53° 10′ 23″, and the longitude is 99° 43′ 26″. These results must be considered as approximate, especially the longitude, as we were not provided with the instruments necessary for making close determinations.

The south end of the lake being open is subject to high winds and rough water.

A fairly accurate survey was made of the northwest shore of Cross lake, locating also the islands and some points on the east shore. Soundings were also taken which indicate a wide range of variation in depth of water. In the north and south the water is very deep with a channel between these points of 12 to 30 feet in depth. An examination of Cranberry bay and Lamb's bay, two of the possible outlets for the proposed canal, indicates a sufficient depth of water within a short distance from shore.

Cross Lake to Cedar Lake.

The connecting link between Cedar lake and Cross lake is formed by a section of the Saskatchewan river, 6 miles in length and 1,200 feet wide at its narrowest point. The most important feature in this stretch is the Demi-Charge rapid, which

occurs at its outlet into Cross lake. The river is here partially obstructed by two islands, Spruce island on the south and Calico island on the north side.

The distance between Spruce island and the north shore is 1,200 feet, but there is, in addition to this, a large volume of water flowing through the channel to the south side of Spruce island.

Above the Demi-Charge the current is strong until Anchor point is reached. Between Anchor point and Flying Post rapids there is a wide lake-like expansion with little current and having a depth of from 7 to 12 feet.

The Flying Post rapids is very shallow in places with a boulder-strewn bottom having only 2 or 3 feet of water, but there is a narrow channel just west of Dividing island which is 5 to 7 feet in depth. The river is narrower and deeper on the west side of Dividing island, but very shallow on the east side. Dividing island is low and rocky, of the same formation as the surrounding country.

About a mile above Dividing island is the Narrows, which is a very narrow passage between Moose island and the south shore, and forms the only navigable channel by which entrance may be made into the river from Cedar lake. To the north of Moose island there is a wide but very shallow channel which is not safe to navigate with any kind of craft.

The river runs in a southeasterly direction and the southwest shore is quite high in many places and is rocky throughout. The northeast shore is also rocky, but is low and was flooded in many places in 1912.

Cedar Lake.

Cedar lake is a quite large expanse of water about 40 miles in length and 12 miles in width at its widest part, exclusive of the north arm which is, in itself, about twenty miles long. It is studded with islands at both the east and west ends, but with a large open expanse in the centre. It is partially divided by a long, narrow peninsula ending in Rabbit point and extending from the north shore to within about 5 miles of High portage on the south shore.

The regular canoe route is around by the north shore to 'the Crossing,' thence to Rabbit point and from there to the Narrows, while the larger craft go direct from Duncan island to Rabbit point, which gives a course about due east, magnetic. The depth of the water along the boat channel is 25 to 35 feet, except near Duncan island, off Rabbit point, and in the immediate vicinity of the Narrows. As stated elsewhere in this report, the water is only 3 to 4 feet deep off Rabbit point during low water according to Captain Ross. The water is 8 feet deep at the Narrows but deepens rapidly towards the west to 25 feet. While the water is known to be shallow at Duncan island there is no definite information as to the exact depth.

The west end of the lake is affected to a considerable extent by the deposit of silt, which is more noticeable, however, in the lower reaches of the Saskatchewan river where it empties into the lake. This material will probably all be removed by the increased current due to the lowering of the lake, but should any remain it will be very easy of removal.

The shores and islands of Cedar lake are mostly rocky and covered with spruce and poplar, but in some places they are low and lead to muskeg in the interior. About the mouth of the river, however, there is an immense reed bed growing on the soft silt deposited from the over-charged waters.

The central portion of the lake is wind swept, and great care should be exercised in navigating with small craft. It is not safe to attempt to cross the main body of the lake in canoes.

Saskatchewan River.

That portion of the Saskatchewan between The Pas and Cedar lake forms the third link in the chain of the proposed scheme of drainage, but is the second in

importance. This river is about 800 feet wide at The Pas at its narrowest point and it varies from 200 to 1,500 feet or more in its course to Cedar lake. Above The Pas there is a very wide open stretch of river which suddenly narrows and turns to the left at The Pas, with the result that in periods of high water the Saskatchewan below The Pas cannot accommodate the flood and the water rushes up the Pasquia river with great velocity and enters Pasquia lake and the low lands surrounding the lake. This has the effect of preventing any rise in the water at Cedar lake for two or three weeks after the flood commences at The Pas and will prove of great value in any scheme of drainage which aims only at the relief of lands lying below The Pas, but will effectually prevent the benefits extended to the lands below The Pas from being enjoyed to any great extent by the lands above The Pas.

According to Dr. Klotz's scale of distances it is 76 miles from The Pas to Cedar Lake Post, but a careful scaling of his plan indicates but 72 miles. This is by way of the main Saskatchewan, while the distance by way of the Summerberry river is generally accepted as 13 miles farther. The first point at which the Saskatchewan breaks away from its main channel is at a point 4¾ miles below The Pas where 'the Little River' is formed. This is the regular steamboat channel, except at very low water, and affords an excellent short cut returning to the main channel at mile 15½. The next offshoot is the Summerberry, which leaves the main channel at a point about 18½ miles below The Pas and, after approaching to within about four miles of Moose lake, turns to the south and joining its waters with another offshoot from the parent stream, flows into Cedar lake some miles north of the point at which the main channel enters.

About two miles below the head of the Summerberry river there is a point known locally as the Wooden Tent. The water is very shallow here except for a narrow channel on the north side, and the bottom is hard and strewn with boulders. In low water there is a rapid here and some work may be necessary at this point, but it is so near the western boundary of the area sought to be drained as to make it somewhat doubtful as to the advantages to be derived from such work.

There is more rock and hard bottom at the foot of Hill island, about 38 miles below The Pas, at the Frying Pan and at a point 3½ miles above Cedar lake. There is also a slight rapid opposite Poplar point called the Poplar Point rapid, but none of these rapids are noticeable except at low water.

Erosion due to increased velocity caused by lowering Cedar lake will have little effect at these points and it will be necessary to do some excavating, but the depth and amount of such excavation cannot be determined until a survey and profile of the river be made.

The usual delta formation exists at the approach of the river to Cedar lake, and out of the numerous channels already in existence it will be necessary to choose the one best suited to afford an outlet for all the waters discharged by the river, having in view the requirements of navigation as well as drainage.

Moose Lake.

Moose lake is a large lake of very deep bays, and Moose Lake Post at the south end of the lake is about forty miles north from Cedar Lake Post.

The south end of Moose lake is only about 6 miles from the north arm of Cedar lake, but the two lakes are not connected at this point. In Mr. Ogilvie's 1911 report he states that there are two outlets to Moose lake, one of which is through the Sturgeon river, but Mr. Lamb, of Moose lake, informs me that such is not the case. The Sturgeon river takes its rise in a muskeg south of Moose lake and flows south into the north arm of Cedar lake.

The outlet of Moose lake is through Moose creek, which is less than one hundred feet wide and has a uniform depth of about fifteen feet. I saw no evidence of any

rapid or hard bottom in this stream, but found a bar of mud in Moose lake just at the mouth of the creek on which the water was only two feet in depth at the time of my visit. Moose creek is four miles in length and joins Moose lake with the Summerberry river. At periods of low water Moose lake empties into the Summerberry through this creek but during high water the procedure is reversed and the Summerberry empties a considerable portion of its waters into Moose lake. The waters of the Summerberry are heavily charged with silt which is held in suspension by the rapid motion of the water, but contact with the still waters of the lake causes the precipitation of the silt and the formation of the mud bar mentioned above.

This bar is a menace to navigation and might be avoided by the construction of a short canal on one side with a gate at the south end. It is unlikely, however, that the Moose Lake route will be much used after construction work on the Hudson's Bay railway is completed. At the present time this route is used to take supplies, etc., through to Cormorant lake. It is also used in the Moose lake fishing trade and by the Hudson's Bay Company.

The lowering of Cedar lake would probably put a stop to the backflow into Moose lake, and thus prevent the formation of the bar.

It is not known at present whether it is necessary or not to lower the waters of Moose lake in order to drain the surrounding lands. It might be an advantage to confine the flow from Moose lake to periods of low water. This regulation of the flow would not only be a great advantage to drainage but could be made of still greater value in the proposed power development at Grand rapids by storing the water in Moose lake and its feeders, Cormorant and Clearwater lakes, for use in winter when the discharge of the Saskatchewan is but half the normal. Cross lake and Cedar lake would also be available for storage after the period of highest water had passed.

Elevations.

On September 12, 1911, a geodetic survey was completed connecting Stephen, Minn., U.S.A., with Winnipeg Beach on lake Winnipeg, and a board gauge placed on the south side of the Government wharf there. The elevation of the zero of this gauge was found to be 712·16 above sea-level and the elevation of the surface of the water was 715·06.

During the month of September and the first thirteen days of October, 1912, a record of the readings on this gauge was kept by the Public Works Department, and during the same period a record of the readings on a gauge at the mouth of the Saskatchewan river, near Grand rapids, was kept by the Manitoba Hydrographic Survey. The readings at Winnipeg Beach vary greatly from day to day and seem to be seriously affected by wave movements, so that it is difficult to make comparisons between the two gauges.

A careful comparison of the two sets of readings, however, shows two periods which seem to be influenced by similar conditions. The first period from the 7th to the 10th September, inclusive, at Winnipeg Beach seems to correspond to the period from the 6th to the 9th of September, inclusive, at Grand rapids. During the period 7th to 10th September the mean of the gauge readings at Winnipeg Beach was 4·05 feet, while during the period 6th to 9th of September at Grand rapids the mean of the reading was ·60 feet. From this it will be seen that:—

Zero of gauge at Winnipeg beach is.	712·16
Mean of gauge readings at Winnipeg beach (September 7 to 10)	7·05
Elevation of surface of lake Winnipeg.	716·21
Mean of gauge readings at Grand rapids, September 6 to 9. . . .	·60
Zero of gauge at Grand rapids.	715·61

This period is chosen because the variations in the gauge readings seem to be somewhat similar. There is a condition of high water at the north end of the lake and low water at the south end on September 5 and 6. This indicates a south wind apparently extending over the entire length of the lake, but extreme low water did not occur at the south end until September 6, whereas extreme high water at the north end occurred on September 5—a difference of one day. For these reasons I have compared the period 6th, 7th, 8th and 9th at Grand Rapids with the period 7th, 8th, 9th and 10th at Winnipeg Beach.

The gauge readings at Winnipeg Beach were so uniform as to indicate a comparative calm, while there seems to have been a slight local disturbance at Grand rapids.

The second period for comparison is September 16, 17 and 18 at Winnipeg Beach and September 17, 18 and 19 at Grand rapids. The gauge reading at Winnipeg Beach on September 17 was the mean of the three daily readings, and the gauge stood at 3·70 feet. On September 18 the gauge at Grand rapids read ·51 feet which was the mean for the period under consideration. Applying these results as in the first period we have:—

Zero of gauge at Winnipeg Beach	712·16
Gauge reading at Winnipeg Beach, September 17	3·70
Elevation surface lake Winnipeg at Winnipeg Beach, September 17, and Grand rapids, September 18	715·86
Gauge reading at Grand rapids, September 18	·51
Zero of gauge at Grand rapids	715·35

During this period the variations were very similar, following a storm at the south end.

The average of all the gauge readings at Winnipeg Beach for September and the first thirteen days of October, 1912, compared with the average at Grand rapids for the same period is as follows:—

Zero of gauge at Winnipeg Beach (geodetic survey)	712·16
Average of 41 gauge readings at Winnipeg Beach	4·03
Average elevation of surface of lake Winnipeg during the period.	716·19
Average of 41 gauge readings at Grand rapids	·69
Zero of gauge at Grand rapids	715·50

Recapitulation.

Zero of gauge at Grand rapids, based on observation during first period	715·61
Zero of gauge at Grand Rapids, based on observation during second period	715·35
Mean of the two determinations	715·48
Zero of gauge at Grand rapids based on average of 41 readings	715·50

From these considerations I am led to adopt 715·50 as the elevation of the zero of the gauge at Grand rapids instead of 711·43, as assumed by Mr. Patterson. The average surface elevation of lake Winnipeg for the 41 days under consideration was 716·19, while the mean elevation for the two periods cited above was 716·03.

I have therefore decided to take 716 feet above sea-level as the elevation of the surface of lake Winnipeg during September and the first half of October, 1912.

The year 1912 was a high-water year, but not as high as 1908. Extreme high water at The Pas was about two feet higher in 1912 than in 1911. This would mean a variation of about one foot or less at lake Winnipeg, which would make the elevation of lake Winnipeg 715 feet in 1911. This accords with the elevation determined by the Geodetic Survey in that year. As 1911 was a year of little more than average elevations, I adopted 715 feet above sea-level as the average elevation of the surface of lake Winnipeg. This agrees with Mr. Ogilvie's views, as expressed in his 1911 report.

A careful survey of the river between lake Winnipeg and Cross lake made by Mr. E. B. Patterson for the Manitoba Hydrographic Survey, in 1912, shows the difference in elevation of these two lakes to be 105 feet, which makes the elevation of Cross lake 820 feet.

Mr. Ogilvie, in his 1911 report, gives the difference of elevation of Cross lake and Cedar lake at 15 feet, and the elevation of Winnipegosis as the same as Cedar lake. This would give an elevation of 835 for Cedar lake and Winnipegosis.

The elevation of the zero of the gauge placed by the Public Works Department on the upstream side of the boat landing at The Pas is given as 845·45. The reading on this gauge at extreme high water in 1912 was 13·6, which makes the maximum elevation of the water at The Pas during the year 1912, 859-05. The maximum for 1911 was 856·90.

The best information at present available would seem to indicate the following elevations:—

Location.	Elevation, 1911.	Elevation, 1912.
Lake Winnipeg	715	716
Cross lake	820	821
Cedar lake	835	836
Lake Winnipegosis	835	836
Moose lake	846	846
Clearwater lake	860	860
The Pas	857	859

The elevation of Moose lake and Clearwater lake were taken from White's book of Altitudes, while the elevations at The Pas are taken from the gauge heights recorded by the Public Works Department for the years given.

From this table it will be seen that the fall between The Pas and Cedar lake is about 23 feet during high water. The distance is about 75 miles, according to the plan of Dr. Klotz, but the fall practically all occurs in a distance of 72 miles, and may be taken at ·31 feet per mile. This agrees very closely with Mr. Ogilvie's determination of the fall, although his elevations are considerably different from those given herein. In low water the fall would be somewhat less as the water rises and falls through a much greater range at The Pas than at Cedar lake. Between October 16 and November 30, 1912, the surface of Cedar lake fell 2 feet while, during the same length of time but three weeks earlier in the season, the surface of the river at The Pas fell slightly more than 6 feet. If, then, we consider that during the high-water period the water at Cedar lake remained at a comparatively uniform elevation and by November 1 had only fallen about 1½ feet, while on the same date at The Pas it was 6 feet lower than it was during nearly the whole of September, it is apparent that the probable fall between The Pas and Cedar lake on November 1, 1912, was only 18½ feet, and it might even be less than this at times.

Since the elevation here given for Cedar lake depends on a different survey altogether from the elevation given for The Pas, the conclusions drawn from these elevations must be considered as a rough approximation.

Discharge.

Very little is as yet known regarding the discharge of the Saskatchewan river at The Pas. In the year 1909, Mr. Forward, acting for the Public Works Department, made a measurement by means of floats, and found the discharge to be 25,210 second feet. From this he estimated the discharge at maximum flow to be 105,000 feet per second.

In 1911, the Department of Public Works had two meterings taken and found the discharge to be 42,637 second feet on August 9, and 23,177 on September 29.

On October 22, 1912, a metering was made for the Manitoba Hydrographic Survey, in which the discharge was found to be 38,122 feet per second. Using the cross-section given, it is possible to form a rough idea of the discharge at other gauge heights. From this it appears that the maximum discharge for 1912 was about 76,000 second feet, and in 1908 it must have been about 105,000 second feet, as given by Mr. Forward.

It does not appear that any measurements have ever been made between The Pas and Grand Rapids.

In 1910, Mr. Ogilvie made a metering at the head of Grand rapids, and, acting under your instructions, the Manitoba Hydrographic Survey had three meterings made in 1912 at the station established by Mr. Ogilvie in 1910. From the information thus obtained, a fairly complete curve has been worked out. Drawing on this information, I find that the discharge at the maximum gauge height during the period of observation in 1912 was 67,950 second feet, and the minimum 31,720 second feet.

This shows a considerably greater maximum discharge at The Pas than at Grand Rapids, which was to be expected from the extensive storage facilities afforded by the lakes and flooded area between the two points. On the completion of any efficient scheme of drainage, however, this difference in discharge between The Pas and Grand Rapids would almost entirely disappear.

The available information regarding gauge heights and discharge of the Saskatchewan river below the Forks is very meagre, and it is important that metering stations be established and a daily record of gauge heights be kept at several points between the Forks and Grand Rapids. In addition to the stations at Grand Rapids and The Pas, there should be at least three others established, viz., one below the Forks, one at the Sipanok channel and one near the Narrows. With a series of meterings and a record of daily gauge readings at these five stations, the information regarding discharge, storage, etc., at different stages of water would be fairly complete. This information is absolutely necessary to permit of an intelligent solution of the problems involved in the proposed scheme.

The Plans.

The plans accompanying this report were compiled from the best information obtainable at the present time. The plan of part of Cedar lake and Cross lake was prepared from notes of our 1912 survey, which was hurriedly made, and is not intended to be more than a rough approximation except the lower half mile of the river and Cross lake, which was more carefully done and is fairly accurate.

The basis of the field plan was Mr. Ogilvie's plan accompanying his report of 1911. Some alterations and numerous additions have been made to this plan, but no attempt is made to correct the location of Cross lake, which is slightly out of position on the map. Much of the information regarding small lakes and islands distant from the Saskatchewan river has been gleaned from conversations with Mr. Lamb, of Moose Creek, and other residents. The elevation of the different lakes was determined, as explained in this report.

THE DRAINAGE SCHEME.

As has been suggested elsewhere in this report, the key to the drainage scheme is the link between Cedar lake and Cross lake. Either the river must be deepened between these two lakes sufficiently to lower Cedar lake the required amount, or an independent route for a canal must be found, or a combination of these two schemes.

In attempting to determine the most feasible and economical route for this canal, there are so many unknown factors to be dealt with that it renders the problem quite impossible of solution at present. While it is not possible to fix the location of this canal nor to design it in detail with the information at hand, it is quite safe to discuss its requirements and, in a general way, some of the features that will affect the location.

From the discharge measurements taken at the Pas it seems very probable that in the years 1901 and 1908 there was, for a short time at least, in the neighbourhood of 100,000 second feet passing this point, while at Grand Rapids the maximum discharge was probably over 70,000 second feet. Mr. Forward estimated the maximum discharge at Grand Rapids to be 66,684 second feet, but this is less than the actual discharge found by Mr. Patterson in 1912, when the flow was considerably less than the maximum.

No measurements have been made of the discharge between Cedar and Cross lakes, but it may be assumed to be the same as at Grand Rapids, without material error.

Such a flood as this would, under the present conditions, turn the whole country between the ridge on which The Pas stands and Cedar lake into an immense lake which would continue to rise until the discharge at The Pas had subsided to 70,000 second feet.

As soon as the flood at The Pas decreased below 70,000 second feet the waters would begin to recede from the flooded area. In any drainage scheme designed to confine these waters to the bed of the Saskatchewan at such an elevation as to prevent any flooding of the drainage basin the channel between Cedar lake and Cross lake would require to have a capacity of at least 100,000 second feet without raising the surface at Cedar lake above an elevation of 824 feet, or four feet above Cross lake. We can hardly hope to accomplish this by any improvement in the river alone, as there is not in all cases sufficient width to accommodate this water within the velocity limit prescribed by this restricted fall of four feet between the two lakes. The most economical scheme would seem to be a low-water canal capable of discharging about 50,000 second feet, and which, reaching its capacity, would overflow into the river, which should be deepened the required amount at the Cedar lake end. Such a canal would require to be about 1,200 feet wide and 10 feet deep at Cross lake, with a fall of 1·44 feet in 10,000.

It would be better to construct the canal with a cross-section of say 900 feet in width for the lower 6 feet in depth, and widening the portion above this to give the desired capacity. This would preserve the depth in the canal at 6 feet during the spring and fall, and thus avoid shortening the season of navigation.

The canal should be constructed first and this would leave the bed of the river dry except in very high water. The unwatering of the river bed would greatly facilitate the work of excavation, as the current is so swift in the rapids as to render dredging operations difficult. It would only be necessary to deepen the upper end from the Narrows down to the foot of Flying Post rapids, and only to the width and depth actually shown to be necessary by experience after the construction of the canal.

There are five possible courses marked on the plan, of which the length and approximate yardage are as follows:—

							Yards.
A-B	the length	is 24,000	feet,	cubical	content	is........	16,000,000
A-F	"	" 30,600	"	"	"	....	16,300,000
A-E	"	" 31,500	"	"	"	....	15,000,000
C-D	"	" 24,000	"	"	"	....	14,120,000
C-F	"	" 25,500	"	"	"	....	12,870,000

From this it will be seen that the most economical course will probably be found to be C-F, although this depends almost entirely on the proportion of rock encountered, which is at present an unknown quantity.

A rough idea of the cost may be obtained by taking 40 cents as the average cost of the excavation.

Before this work is completed, and the water let out of Cedar lake, it will be necessary to make a cut through the shoal at Rabbit point, and deepen the channel at Duncan island at the west end of Cedar lake. A deeper channel may possibly be found farther south from Rabbit point, as no soundings were taken there, but it is reported to be shallow.

No further details of this work can be given at present, nor of the work necessary to be done in the Saskatchewan river between Cedar lake and The Pas.

It will be found to be less expensive to deepen the river, wherever necessary, before the velocity of the water is increased by the lowering of Cedar lake. It might, however, be possible, during low water, to divert the greater portion of the flow to the Summerberry by means of a temporary dam at the forks of the Summerberry and thus unwater the main Saskatchewan, but this could not be done except in very low water, owing to the small capacity of the Summerberry channel.

Immediately following the lowering of the water in Cedar lake, the velocity in the Saskatchewan and Summerberry will be increased by an unknown and variable amount, probably two or three times its present velocity, which will cause considerable erosion, particularly in the vicinity of Cedar lake. After the bed of the river assumes its final form, the velocity of the water will be found to have increased about 25 per cent above the present velocity, and the power to transport silt will have increased about 75 per cent.

Owing to the absence of rock in the Summerberry channel it seems quite probable that, if left to itself, the river will eventually adopt this channel to the exclusion of all others. There are two things that will militate against this, and they are: First, the longer course, and second, the narrowness of the channel. The channel could be widened artificially but the cost would probably be greater than for deepening the main channel at the rapids between The Pas and Cedar lake. Another objection to the adoption of the Summerberry channel is that the main channel would soon become unnavigable.

SOILS.

During the season of 1912 very few samples of soil were taken owing to the prevalence of high water which prevented any examination of the soils of the interior. A few samples were secured in the vicinity of the Saskatchewan river, but no report as to their value has yet been received from the Dominion Chemist. and, in any case, they cannot be considered as representative of the interior soils.

In taking samples from the vicinity of the river, I felt I was simply repeating what had been done by Mr. Ogilvie in 1911, without adding materially to the information already gained.

So far as can be determined at present the soils of the district between The Pas and Cedar lake are practically all alluvial, having been formed by the precipitation of the sediment carried down by the river. As has been said before, the waters of the Saskatchewan are very heavily charged with silt, especially during the

flood period. When the river overflows, the water rushes away into the interior lakes and marshes, and the silt, which has been held in suspension while the water was in motion, settles to the bottom and leaves the water comparatively clear, except for the colouring due to the presence of vegetation. As the flood recedes, this deposit is left on the land, and the operation is repeated at the next overflow.

The water gradually clears on its course down stream resulting in the inevitable shoals and bars in the river, but the greatest precipitation takes place when the back water from Cedar lake is reached. After passing through Cedar lake and the 6-mile link of the river between Cedar and Cross lakes, the water is found to be comparatively free from sediment. In the northern extensions of Cedar and Cross lakes the water is of crystalline clearness and purity.

The certain result of this periodical flooding must be that the coarser particles held in suspension by the water, being heavier, will be deposited in or near the river bed at the first slight diminution of the velocity, and only the very fine particles would be carried into the interior. This makes it especially desirable that samples be obtained at points remote from any channel of the Saskatchewan, past or present.

In the year 1911 the late Mr. Ogilvie secured twenty-two samples of soils in this section and had them analyzed by Mr. Shutt, Dominion Chemist. While Mr. Shutt's report on these soils is quite favourable, an intimate knowledge of the district from which the samples were taken is necessary to an intelligent understanding of the situation. For instance, sample No. 33 is from a very high stony ridge nearly one hundred feet above the water, as stated in Mr. Ogilvie's report of 1911. Samples Nos. 32 and 38 are from high ground more or less stony and above the reach of high water. The evidence presented by these three samples should carry very little weight, as the areas they represent are very limited, and bear no resemblance to the great flooded area. The remainder of the samples are practically all from near the river, and fairly represent the soils along the banks. These, however, are certainly dissimilar and probably inferior to the soils of the interior. Samples from the interior can be obtained only with the greatest difficulty owing, as stated above, to the presence of water, and it may be necessary to use a specially constructed instrument for this purpose. It would probably be less difficult in seasons of very low water.

In all cases where the water is not too deep, there is a very rank growth of grass, while in the wetter portions rushes and some coarser varieties of grass extend as far as the eye can reach. The growth seems to indicate a fertile soil, the absence of trees being easily accounted for by the continuous presence of water at or above the surface of the ground.

NAVIGATION.

The navigation of the lower Saskatchewan river has been confined to boats of about 3 feet draught, and there is no attempt to go farther down than Cedar lake. In the days before the construction of the Canadian Pacific railway, the river was navigated all the way to the head of Grand rapids by York boats and even steamboats, which were hauled up the Red Rock and upper rapids by means of a line. Freight of all kinds intended for the west was unloaded at the foot of Grand rapids by boats plying on lake Winnipeg. From here it was transferred to the head of the rapids by means of a tramway, using horse-drawn cars.

Should the power at Grand rapids be developed and locks constructed, lake Winnipeg vessels could pass the rapids and ascend the river to Cross lake. The power dam at Grand rapids should be of such height as to flood out Red Rock rapids completely, and so reduce the fall in Cross Lake rapids as to admit of easy navigation without raising the elevation of Cross lake.

The construction of the proposed drainage canal between Cross lake and Cedar lake will reduce the fall beween these lakes from 15 feet to about 4 feet. This fall would produce a current of about 3 miles per hour and should not present serious difficulty to navigation for the short run of five miles to Cedar lake.

When the shoals at Rabbit point and Duncan island have been removed, as recommended herein, there will be no obstruction to navigation across Cedar lake. The only vessels running from The Pas to Cedar lake at present are those of the Ross Navigation Company, and the only business is the carrying of supplies to Cedar Lake post. The direct route from The Pas to Cedar lake is by way of the main Saskatchewan, but, as the volume of business at Cedar lake is very small, the trip is generally made by way of the Summerberry channel to Moose lake and thence to Cedar Lake post, returning by the direct route.

In the winter there is a small trading settlement at Pine Bluff and a smaller one at Hill island, but one trip in the fall is all that is necessary to supply these. There is also a little trading done in the winter time at Poplar point, but this is south of the main Saskatchewan and is supplied from Cedar Lake post.

At the present time the route by way of the Summerberry channel is more important than by the main channel, since the bulk of the trade is to Moose lake and through Moose lake to Cormorant lake. The trade to Cormorant lake will be cut off, however, on the completion of that portion of the Hudson Bay railway from The Pas to this lake. The only white settlement in the district at present is at The Pas. On the completion of the drainage works and the opening up of the large area to the south for settlement, the navigation of the main Saskatchewan will become most important, and the cutting out of the rapids mentioned elsewhere in this report will distribute the fall along the whole course between Cedar lake and The Pas, and will improve the navigation of this channel very materially.

Thus, with the development of the power at Grand rapids and the construction of drainage works proposed in this report, little else will be required to make the Saskatchewan navigable from The Pas to lake Winnipeg. The only additional expense required will be the construction of locks at Grand rapids and raising the dam high enough to flood Red Rock and Cross Lake rapids. It may be found that a lock will be necessary at Cross Lake rapids and, if so, this may be very readily constructed on the north side.

It will, of course, be advisable to keep a dredge in the river for the removal of any small bars that may form from time to time at the west end of Cedar lake.

These bars are at present a menace to navigation as are also some of the other shoals in low water.

CLIMATE.

A daily record was kept of the readings of the thermometer and barometer during the months of August, September and October, as follows:—

TEMPERATURE AND BAROMETRIC READINGS.

Date.	Temperature.		Barometer.		Remarks.
1912.	Max.	Min.	A.M.	P.M.	
August 2	73	54	30·15	30·00	
" 3	77	53	30·25	29·91	Fair.
" 4	74	54	28·91	29·97	Fair.
" 5	75	52	28·72	28·85	Cloudy.
" 6	74	46	28·79	28·70	Cloudy and rain.
" 7	77	51	29·00	28·81	Cloudy and fog.
" 8	76	52	28·95	29·21	Fog; fine.
" 9	75	54	28·83	28·91	Fair.
" 10	80	55	28·80	28·65	Fair.
" 11	76	53	28·53	28·52	Rain.
" 12	77	55	28·00	27·70	Rain and cold.
" 13	70	59	28·74	28·51	Cloudy and cold.
" 14	72	57	28·71	28·76	Fair and cold.
" 15	76	54	28·79	29·05	Fair and cold.
" 16	76	58	29·10	28·81	Cloudy.
" 17	74	57	28·85	28·91	Cloudy.
" 18	76	50	28·87	28·81	Fair.
" 19	78	51	28·91	28·87	Cloudy.
" 20	78	52	28·95	28·70	Cloudy.
" 21	68	50	28·62	28·60	Rain.
" 22	78	51	28·75	28·76	Cloudy and cold.
" 23	79	49	28·73	28·56	Cloudy and cold.
" 24	70	47	28·59	28·70	Rain.
" 25	76	48	28·72	28·70	Rain and cold.
" 26	77	42	28·90	28·92	Cloudy.
" 27	69	43	29·00	28·91	Cloudy.
" 28	68	46	28·95	28·93	Rain.
" 29	68	44	28·77	28·55	Rain.
" 30	67	53	28·54	28·62	Rain.
" 31	75	50	28·73	28·42	Cloudy.
Sept. 1	77	47	28·51	28·62	Rain.
" 2	76	46	28·79	28·85	Fine
" 3	75	48	28·81	28·75	Rain.
" 4	73	46	28·79	28·85	Rain.
" 5	78	52	28·75	27·50	Rain and gales.
" 6	67	53	27·75	28·70	Rain and gales.
" 7	69	49	28·66	28·74	Fine.
" 8	68	49	28·73	28·79	Fine.
" 9	69	50	28·74	28·74	Fine.
" 10	70	56	28·90	28·79	Fine.
" 11	72	54	29·10	28·95	Fine.
" 12	76	54	28·90	29·00	Fine; rain.
" 13	74	53	28·62	28·82	Rain and gales.
" 14	70	52	29·30	28·71	Rain and gales.
" 15	66	28	29·45	29·45	Fair and cold.
" 16	65	33	29·10	28·95	Cloudy and cold.
" 17	66	34	28·95	28·85	Cloudy and cold.
" 18	63	40	29·70	28·90	Fine; rain.
" 19	64	41	29·21	29·00	Rain and gales.
" 20	64	40	28·50	28·85	Rain and gales.
" 21	66	39	29·10	28·55	Rain and gales.
" 22	66	41	28·45	28·30	Rain and snow.
" 23	57	30	28·91	28·90	Snow flurries.
" 24	56	27	29·25	29·10	Cloudy and cold.
" 25	57	26	29·20	29·15	Fine.
" 26	54	24	29·10	28·95	Snow flurries.
" 27	44	30	29·10	29·25	Rain and snow.
" 28	47	27	29·45	29·40	Cold and windy.
" 29	54	29	29·05	29·32	Fair and cold
" 30	57	30	29·00	28·85	Fair and cold.

TEMPERATURE AND BAROMETRIC READINGS—*Concluded.*

Date.		Temperature.		Barometer.		Remarks.
1912.		Max.	Min.	A. M.	P. M.	
Oct.	1	60	36	28·75	28·60	Cloudy and rain.
"	2	64	37	28·49	28·45	Fair and mild.
"	3	60	41	28·50	28·40	Cloudy and cold.
"	4	61	40	28·50	28·57	Cold ; rain.
"	5	49	37	29·10	29·15	Cold ; rain.
"	6	47	31	29·15	29·00	Cloudy and cold.
"	7	51	34	28·70	28·70	Cloudy, rain.
"	8	48	35	28·75	28·95	Rain and snow.
"	9	48	30	29 23	29 12	Cloudy and cold.
"	10	43	26	28·91	28·87	Cloudy and cold.
"	11	46	34	29·00	28·80	Fine.
"	12	47	33	29·15	29·10	Cloudy and gales.
"	13	54	24	28·75	28·60	Cloudy and cold.
"	14	55	27	28 82	28·89	Fair and cold.
"	15	50	32	29·10	28·95	Fair and mild.
"	16	46	34	29·00	28·70	Fair and mild.
"	17	49	33	28·80	28·82	Cloudy and cold.
"	18	47	36	28·81	28·85	Light snow.
"	19	45	35	29·00	28·80	Fair.
"	20	41	33	28·75	28·55	Snow, 3 inches.
"	21	41	28	28·70	28·90	Fair and cold.
"	22	40	27	29·15	29 00	Fair and cold.
"	23	38	27	28·32	28·82	Fair and milder.
"	24	39	28	28·41	28·63	
"	25	47	29	29 15	28·94	

Fine is intended to mean clear.
Fair is intended to mean partly cloudy.

The following summary shows the highest and lowest readings and the average temperatures for each month, together with the number of times the mercury fell below the freezing point:—

August—

Highest readings on 10th	80°
Lowest readings on 26th	42°
Average maximum	73°·5
" minimum	49°·6
Number of times below 32°	None.

September—

Highest reading on 5th	78°
Lowest reading on 26th	24°
Average maximum	62°·2
" minimum	40°·9
Number of times below 32°	9

October (1st to 25th)—

Highest reading on 2nd	64°
Lowest reading on 13th	24°
Average maximum	48°·5
" minimum	32°·3
Number of times below 32°	11

The first light snow flurry was on September 22, but no snow to speak of fell until October 20, when there was a fall of three inches which remained on the ground for several days. The weather throughout the season was unusually cool and wet.

ASTRONOMICAL.

No instruments for precise determinations of latitude or longitude were included in our outfit, as these were not considered necessary. The approximate location of the different points visited seemed to be all that was required.

The main points in the district were all located by Mr. Ogilvie in 1911, except Cross lake. I made approximate determinations at The Pas Forks, Cedar Lake Post and at Cross lake, which were the only points at which the sky was sufficiently clear for making observations. It was not very satisfactory at Cedar lake on account of clouds. In every case the meridian was determined by observing Polaris, but the watch correction was found by both sun and star observations.

The point of observation on Cross lake was at the foot of Demi Charge rapid on the north shore. The latitude of this point was found to be 53° 10′ 24″ and the longitude 99° 42′ 13″ W.

No correction was made for the rate of the watch, as it showed practically no variation during the first ten days at Cross Lake camp, although changing considerably later.

The declination of the needle was found, from a number of observations taken at Cross Lake camp, to average 17° 40′ east.

The location of the west arm of Moose lake has been determined by the 15th Base Line which has been run under the Surveyor General's instructions eastward from the second meridian to intersect the lake. Other lines have been started and are being extended across the district this winter, and these will give a definite location to all points not already determined.

All of which is respectfully submitted.

THOS. H. DUNN, *C.E., O.L.S.*
Engineer in Charge.

Dated at Ottawa, this 7th day of March, 1913.

No. 12.

REPORT OF H. E. M. KENSIT.

OTTAWA, April 14, 1913.

J. B. CHALLIES, Esq.,
Superintendent, Water-power Branch,
Ottawa.

SOUTH SASKATCHEWAN RIVER.

SIR,—In accordance with your instructions of September 25, 1912, to investigate the sources of power available for pumping water from the South Saskatchewan river for supply to cities and towns in the central portion of South Saskatchewan, I beg to report as follows:—

I have spent the period from September 30 to December 5 in the locality, making a thorough investigation into the nature of the problem and the local conditions affecting it. It will be understood that in accordance with your instructions this did not include any surveys or field work, which still remain to be dealt with.

In company with Mr. J. B. McRae, consulting engineer to the department, and Mr. D. L. McLean, chief engineer, Manitoba Hydrographic Survey, I visited the

South Saskatchewan river near Boldenhurst (Billings Ferry), and at 'the Elbow,' and subsequently I returned alone and made a further careful inspection of the nature of the land near the Elbow.

I have also visited the following places, spending sufficient time in each to collect all available information bearing on the subject, and data of power and water supply under conditions obtaining in such western towns:—Moosejaw, Regina, Weyburn, Saskatoon, Winnipeg, Calgary, Elbow, Tugaske, Medicine Hat, Vancouver, and the developed coal mine of the Consumers' Coal Company on the Lake of the Rivers, 38 miles south of Moosejaw.

I have interviewed the following officials and other gentlemen to whom I am much indebted for information furnished:—

Calgary.

A. S. Dawson, chief engineer, Department of Natural Resources, C.P.R.

John F. Sweeting, industrial agent, western lines, C.P.R.

F. H. Peters, commissioner of irrigation.

Eugene Coste, president, Canadian Western Natural Gas Light, Heat and Power Company.

J. D. Fleet, general manager, Calgary Power Company.

William Georgeson, wholesale merchant, principal in the proposed company to pipe natural gas from Alberta to Moosejaw, Regina, Winnipeg and intermediate points.

R. L. Shimmin, engineer to Mr. Georgeson.

R. A. Brown, city electrical superintendent.

Lethbridge.

Arthur Reid, city electrical superintendent.

Mr. Blanchard, city engineer.

Medicine Hat.

A. K. Grimmer, city engineer.

John McNeely, proprietor Medicine Hat Milling Company.

Mr. Soans, resident engineer, C.P.R.

B. Winter, gas superintendent, C.P.R.

Arthur M. Grace, chief engineer, Southern Alberta Land Company.

Moosejaw.

H. C. Pope, chairman Light, Heat and Power Committee, City Council.

L. W. Rundlett, city commissioner.

W. F. Heal, city commissioner.

T. Martin, division engineer. C.P.R.

J. Antonisen, city engineer.

J. D. Peters, city electrician.

Theodore Kipp, jr., chairman of the Power Committee, Board of Trade.

Mr. Patton, secretary Board of Trade.

W. B. Willoughby, M.P.P., leader of the Opposition, Saskatchewan Legislature.

A. H. Dion, general manager, Moosejaw Street Railway Company.

John C. Chisholm, LL.D., president, and

L. E. Bays, manager, Consumers' Coal Co. Lake of the Rivers Mine, near Moosejaw.

T. Steele, superintending engineer to Mirrlees, Bickerton and Day, makers of Diesel oil engines.

Regina.

A. F. Mantle, Deputy Minister of Agriculture, Government of Saskatchewan.

C. E. McPherson, chairman of Highways Commission, Government of Saskatchewan.

Dr. M. M. Seymour, commissioner, Bureau of Public Health, Government of Saskatchewan.

Senator J. H. Ross, of the Dominion Senate (named as representative of the Saskatchewan Government on the Water Commission to be appointed).

G. A. Mantle, city commissioner.

L. A. Thornton, city commissioner.

Dr. G. A. Charlton, bacteriologist, Department of Agriculture, Government of Saskatchewan.

R. O. Wynne Roberts, consulting waterworks engineer to the city of Regina.

F. McArthur, city engineer.

J. McD. Patton, waterworks superintendent.

Alfred S. Porter, owner of large coal fields near Estevan.

Saskatoon.

Geo. T. Clarke, city engineer.

Weyburn.

Norman Murray, city engineer.

Winnipeg.

Col. Ruttan, city engineer.

Mr. Fillmore, manager Winnipeg Oil Co.

Henry B. Lake, testing engineer and chemist, Canadian Pacific Railway.

Vancouver.

G. R. G. Conway, acting general manager, British Columbia Electric Traction Company.

Mr. Johnstone, chief operating engineer, British Columbia Electric Traction Company.

I have also visited a number of coal, gas and oil plants in operation at various points in the west, closely inquiring into their operation from the managers and operating staffs and obtaining operating costs and financial results where possible.

These included plants in Moosejaw, Medicine Hat, Lethbridge, Saskatoon, Vancouver, Weyburn, but in some cases the particulars as to cost of operation were given in confidence, to be used for estimating purposes only.

I now beg to hand you my report on the sources of power available and the estimated cost of pumping by each method, together with a discussion of various possibilities which appear to deserve further investigation.

Yours respectfully,

H. E. M. KENSIT.

City Water Supply from the South Saskatchewan River.

PREVIOUS INVESTIGATIONS.

The primary object of the investigations herein reported upon was to ascertain what sources of power are available for pumping water from the South Saskatchewan river for municipal supply to the cities of Moosejaw, Regina and Weyburn, and intermediate towns, and the comparative cost of power from such different sources.

Previous reports bearing on this subject have been made by:—

The Commissioner of Irrigation, dated April 2, 1912, to the Department of the Interior.

Mr. T. Aird Murray, C.E., consulting engineer to the province under the Saskatchewan Public Health Act, in 1911.

Messrs. Walter J. Francis & Co., of Montreal, dated June 15, 1911, to the city of Moosejaw.

Brief extracts from the above reports are therefore first given, to show in a general way the proposals made and for the purpose of ready reference to data quoted therefrom.

Notes from 'Report by the Commissioner of Irrigation.

Purpose.—To take from the South Saskatchewan river a supply of water for town purposes and deliver the same by gravity to towns in the Moosejaw and Regina districts.

Quantity.—Has taken the figure of the application of the Saskatchewan Government as 200 cubic feet per second.

The only feasible scheme, in the writer's opinion, is to dam the river and develop enough power to pump the water to a sufficient height on the side hill of the river, the available power has been based on the minimum winter flow. (See below under 'Flow.')

Gravity pipe line.—Circular reinforced concrete pipe covered everywhere by 6 feet of earth. From 10 feet 6 inches to 6 feet 5 inches internal diameter.

Demand for water.—Assumed equal from intake to delivery at Regina, where 50 cubic feet per second is allowed. Total length of 170 miles is therefore divided into four sections having, from the intake, capacities respectively of 200, 150, 100 and 50 cubic feet per second.

Location of dam.—Somewhere in townships 22 or 23 (about 20 miles S.W. of 'the Elbow.'

Flow.—Available L.W. flow assumed at 3,000 cubic feet per second. (See 'Remarks' below.)

Efficiency of turbines and direct connected centrifugal pumps assumed at 52 per cent.

Friction in pipes from pumps to delivery to intake on height of land near river, assumed at 10 per cent.

Quantity required in pipe: 200 c.f.s.

	EL.	
Head on pipe line—		
Intake at Boldenhurst (on height of land)	1,951	
Regina	1,862	
	——	89 ft.
Head at dam—		
Top of dam	1,690	
Natural low water	1,653	
	——	37 ft.
Lift required—		
Canal intake	1,951	
Top of dam	1,690	
	——	261 ft.

Theoretic horse-power required, 12,600.

Summary of estimate of cost—

Cost of dam	$ 1,000,000
Cost of turbines and pumps	189,000
Cost of pressure pipes	184,800
Cost of concrete pipe lines	11,591,531
	$12,965,331

Total cost about $13,000,000.

Remarks on the above.—From the map accompanying the report it appears that the proposed pipe line has to follow a winding route to obtain the necessary contour to reach Regina.

This route is 170 miles long and does not include connection to Moosejaw, about 14 miles by air line north of the pipe line, nor any other town. (See Plate 38.)

This is further referred to under the head of 'cost due to the pipe line.'

The available low-water flow in the river is assumed at 3,000 c.f.s. According to the Department of the Interior's hydrographic survey of the river at S.W. 28-3-5-3, the minimum discharge was on January 9 and 10, 1911, 1,382 c.f.s.

The observations giving this figure covered only a short period, so that it is possible the flow may at times be even less than that given. A margin of 6 per cent on 1,382 leaves 1,300 c.f.s.

From this there must also be deducted the water required for city water supply under the proposed project. This was taken by Mr. Peters at 200 c.f.s. Application was made for rights to divert 100,000,000 gallons per day for this purpose, equal to 185 c.f.s. Subtracting this latter figure from 1,300, as above, leaves 1,115 c.f.s., so that the flow available = 1,115 c.f.s.

Notes from Report by Mr. T. Aird Murray.

Moosejaw.—Storage supply for only 20,000 population. Present supply of about 17 gallons per day necessitates shutting off the supply daily.

Regina.—Present supply only good for about 20,000 population.

Weyburn.—Is in great difficulties. Supply from wells only good for 1,500 population.

(NOTE.—It is understood that, since the date of Mr. Murray's report, the local supplies have, in the above cases, been considerably increased, though still not to an extent to provide for future growth.)

Smaller towns between Regina and Moosejaw have extremely limited water supply.

Plan proposed.—Any scheme for bringing a water supply from the South Saskatchewan river to the Moosejaw and Regina districts must depend entirely upon pumping water over the height of land or tunnelling through the height of land. I am inclined to think that a tunnel scheme will prove the most efficient in every way, combined with the construction of a dam across the river, but exact data are not available.

A 25-foot dam would allow of a gravity cut through the height of land for fourteen miles at an average depth of thirty feet. Water would be delivered to Buffalo lake, sixty-five miles from the Elbow, with a total fall of thirty-eight feet. Buffalo lake is eighteen feet below normal river level at the Elbow, and is seventy-five feet below Moosejaw, 200 feet below Regina and 182 feet below Weyburn.

The water would then have to be pumped to points from which it could gravitate.

Water required for town supply.—Assuming fifty gallons per head per day and 100,000 population each for Moosejaw and Regina, with 100,000 for smaller towns (total, 300,000), we would require 15,000,000 gallons per day.

Powers should be obtained to divert 100,000,000 gallons per day.

Total cost.—$4,000,000 to $5,000,000.

Remarks on the above.—The low-water flow of the river was assumed at 1,349,740,-800 gallons per day, which equals 2,500 cubic feet per second.

Location of pumping station.—It will be observed that with the proposed dam, tunnel and gravity feed to Buffalo lake, all the pumping would have to be done at Buffalo lake. This is generally given on the maps as 'Buffalo Pound lake,' and is about sixteen miles N.E. of Moosejaw. (See Plate 38.)

Notes from Report by Mr. Walter J. Francis, C.E.

This report was made to the city of Moosejaw with reference to the supply of that city only. It deals fully with the sources and development of local water supplies and, in a preliminary way, with the possibilities of supply from the South Saskatchewan river in the event of the local supplies proving insufficient.

The opinion is expressed that 'the South Saskatchewan river must be the ultimate source of water, not only for Moosejaw but for the whole of the south central part of the province. We cannot find any evidences at present of any other water supply suitable for cities of 50,000 population and a densely settled surrounding district. We believe the Saskatchewan to be the proper source, primarily because its supply is derived from glacial districts and, therefore not dependent upon precipitation in the prairie country. It is, moreover, the only continuously flowing supply of any magnitude in the country.'

As to the nature and quality of the water, some extracts from the report are given under the heading of 'The water of the South Saskatchewan river.'

As to the engineering features of a supply from the river, the report states as follows:—

> 'The proposed sources of water supply are the South Saskatchewan river at Elbow . . . and near Riverside in S.W. ¼ section 30, township 21, range 8, west of 3rd meridian. The information obtained in the field has been added to our general knowledge of Saskatchewan and supplemented by authentic governmental and other records.
>
> 'Since leaving Moosejaw. . . . . full consideration has been given to all the facts which we believe to be ample foundation for the recommendations made.
>
> 'South Saskatchewan river, near Riverside . . with a view to a possible pipe line down the Thunder Creek valley (see Plate 38), a number of observations were made with the aneroid to ascertain generally the lowest point over the Divide. It appeared that this occurred in the N.E. quarter of township 21, range 8. The general level through this part of the township is fairly regular. The water level was found to be 250 feet below the prairie level at the edge of the banks, which, in turn, are about fifty feet below the top of the Divide towards Thunder Creek valley. The river possesses the same characteristics at Elbow . . its level varies about thirteen feet from low water. Speaking generally, the water is 270 feet below the prairie level. The exposures on the bank show generally a stiff heavy clay.
>
> 'In order to obtain a supply a pipe line can be constructed from the river to the city. The most feasible route is doubtless that indicated by a black

dotted line on the map (see Plate 38), following the valley of Thunder creek to its source and then crossing the divide about five miles to the river.

'From the engineering point of view there are no serious obstacles. The location of the dam on the river, the details of the pumping station, arrangement and size of pipe line and all such features can only be determined by careful study after surveys. . . . We are inclined to think that the best construction will be found to be a concrete dam in township 21, range 8, to give pondage and furnish hydraulic power for pumping to a filter and thence to a reservoir on the height of land, whence the purified supply would run by gravity in an enclosed pipe to Moosejaw.

'The only real obstacle to this project is its cost, which will probably run into $5,000,000 or more.'

Comparison of scope and cost of the foregoing proposals.

It will be noticed that the Commissioner of Irrigation estimates the cost at about $13,000,000 and Mr. Aird Murray at between $4,000,000 and $5,000,000, and that both figure on an ultimate delivery of about 100,000,000 gallons per day in the same district.

The two estimates, however, really cover quite different proposals.

The estimate of the Commissioner of Irrigation includes the cost of a pumping station at the river and pumping the water to a sufficient height to deliver it by a 170-mile gravity pipe line to the level of the Canadian Pacific railway rails at Regina; also the cost of a complete pipe line.

Mr. Murray's estimate does not include any power station, pumping or pipe line, and delivers the water to Buffalo lake, from whence it has to be pumped to a height from which it can flow by gravity to the towns, at a cost which is not included in the estimate. The distance in an air line from the most southerly point on Buffalo lake is about 16 miles to Moosejaw and 34 miles to Regina.

Both schemes would involve separate pumping plants in each town served, to add the pressure necessary for distribution.

Messrs. Francis & Company's report considers supply to one city only and is hardly comparable with the others. It is, however, of interest in regard to the proposed route for the pipe line, the topographical features of the river and the quality of the water.

Brief Statement of the Problem.

The central portion of southern Saskatchewan is an area with little precipitation and no considerable rivers. Such creeks and lakes as are found in the area do not provide any considerable quantity of water suitable for domestic purposes.

The cities of Moosejaw, Regina and Weyburn draw their present supplies of domestic water wholly or partly from surface wells. The supply is hard and otherwise unsatisfactory and inadequate to provide for the probable future growth of the cities, although large sums have been spent in developing the local resources as far as possible.

The smaller towns between the above-named cities and between Moosejaw and Elbow, on the lines of the Canadian Pacific railway, are also extremely limited in their water supply.

Between the above-mentioned points there are some twenty-six cities, towns and villages, many of which are growing rapidly. An estimate (page 104) based on the latest figures and allowing an average rate of increase of only 15 per cent per annum indicates that these places will have a population of at least 100,000 within the next two years, or about the time it would take to carry out any comprehensive water supply scheme.

Furthermore, within the same area or closely adjacent thereto, the Canadian Pacific, Canadian Northern and Grand Trunk Pacific railroads have built or are building several new lines, and numerous new towns are already established thereon, indicating the probability of a comparatively dense population in the near future.

The situation has been investigated or studied and reported upon at different times by Mr. T. Aird Murray, C.E., of Toronto, Dr. M. M. Seymour, Commissioner of Public Health, Saskatchewan, Messrs. Walter J. Francis and Company of Montreal, the Commissioner of Irrigation and his assistant, Mr. P. M. Sauder, all of whom appear to agree that the ultimate source of town water supply over the said central portion of south Saskatchewan must be from the South Saskatchewan river.

The nearest part of the South Saskatchewan river is at a distance of about 75 to 80 miles in an air line northwest of Moosejaw and proportionately farther from Regina and Weyburn according to the route taken. (Fuller particulars will be found in the body of this report.)

The elevation of the water in the river is considerably below that of the cities of Moosejaw, Regina and Weyburn, and intermediate towns, and the water will have to be pumped to an intake on the height of land near the river bank. This intake must be at a sufficient elevation to give a gravity supply from thence to the above-named cities.

The lift will be from 260 to 330 feet for a gravity supply, and to meet the ultimate needs of the district this will probably require finally about 12,000 horse-power, though the initial installation need not be more than a part of this capacity.

It will therefore be seen that a large amount of power will be required and that the cost of pumping must be carefully considered.

On account of the nature of the river, i. e., its slow flow and absence of natural fall, its great width and the probable lack of suitable foundations for a dam, it cannot be considered a favourable water-power development and would certainly be a somewhat expensive one.

It has therefore been considered advisable to make a thorough investigation of what sources of power other than water-power are available to do this pumping, and what the costs by such other sources would be, compared with one another and with water-power.

The primary object of this report, therefore, is to present suggestions as to what other sources of power are available and practicable, and what the costs would be by each of such methods, taking into consideration both capital and operating costs and giving the final results in terms of the total cost per 1,000 gallons of water lifted to the intake of the gravity pipe line.

ELEVATIONS AND POPULATIONS.

Town.	Population.	Total Population.	Elevation above sea level.
Elbow	250		1,897
Aiktow (estimated)	200		1,792
Bridgeford	100		1,875
Tugaske	400		1,952
Eyebrow	400		2,040
Brownlee	250		2,015
Keeler	80		1,973
Marquis	100		1,931
Tuxford	125		1,928
Belbeck	250		1,890
MOOSEJAW	25,000	27,155	1,746 (*)
Drinkwater	400		1,842
Pitman (estimated)	100		1,862
Rouleau	1,000		1,855
Wilcox	350		1,863
Corinne	50		1,869
Milestone	450		1,880
Lang	300		1,880
Yellow Grass	500		1,868
McTaggart	135		1,850
WEYBURN	4,000	7,285	1,825
Pasquia	50		1,847
Belle Plains	100		1,880
Pense	500		1,859
Grand Coulee	100		1,829
RÉGINA	42,000	42,750	1,864
	77,190	77,190	

(*) On account of hill within city limits, 84 feet, this should be taken as 1830.

Low water of South Saskatchewan river, near Boldenhurst, 1,653.

Elevations at Canadian Pacific railway rail level, from official contours.

Populations per latest estimates of Canadian Pacific Railway Company, unless otherwise stated.

An average increase of 15 per cent per annum would make the above population reach 102,000 in January, 1915.

GENERAL CONSIDERATIONS *re* SOURCES OF POWER.

The object under consideration is to develop power for pumping water at a given point, at the least possible annual expenditure (made up of both annual capital charges and operating costs), that will give the maximum reliability of service.

Three methods are possible:—

(1) The development of a water-power.

(2) The purchase of power in bulk delivered at the pumping station.

(3) The generation of power from fuel, either at the pumping station, or at a distance with electrical transmission.

Alternative (3) covers a large number of possible alternatives which are further detailed on page 123.

The advantages, disadvantages and reliability of each source of power are discussed under the heading relating to that source of power.

No general comparison of the cost of power from different sources can be made that is of any real value over even a small area, as conditions vary so much that each case is a problem in itself. After having ascertained the actual existing con-

ditions as closely as possible, the different methods must be compared by estimates of capital expenditure and operating expenses that will meet those particular conditions.

Thus, taking one of the simplest possible cases, suppose a gas engine and an electric motor of the same rated horse-power, and supplied with gas and electricity at fixed rates. Let these rates be as nearly as possible equivalent under average conditions of operation.

Then if both work at steady full load, that is under best conditions, the advantage would probably be appreciably in favour of the gas engine. If, on the other hand, the load was variable and intermittent, the motor would have the advantage, and the smaller and more variable the load the greater would be the commercial advantage of the electric power.

Again, if the demand for power existed near a coal mine, the power might be developed at the pit mouth by steam or producer gas cheaper than by water-power or oil, but if the demand was at a distance, involving handling and hauling the coal or electric transmission, the conditions might be completely reversed. The cost of electric transmission alone may turn the scale in any particular case as to where and how the power should be developed.

The comparative value of different fuels, such as coal, oil and gas, at different prices, for producing power under similar conditions, and also the equivalent amounts of different fuels to produce the same amount of power, has been ascertained and published by many good authorities and numerous tables of the results could be quoted here. ([1])

Such tables, however, while they give the comparative values of fuels, do not indicate the cost of power, which must also include the other operating costs and the annual capital charges, and the cheapest fuel will not under all conditions give the cheapest power.

Generally speaking, the cost of fuel is about 60 per cent of the operating costs, and the operating costs are about 60 per cent of the total costs, including annual capital charges on the land, buildings and plant, so that fuel costs in terms of total costs are only 60 per cent of 60 per cent, or 36 per cent.

It is therefore evident that the cost of fuel is not the only important item to be considered.

This is illustrated in the table on page 106, which shows the different items of cost expressed as a percentage of the total costs. The figures represent the average of the results obtained in several representative American steam-electric stations, supplying a general light and power load, and are given as a typical example.

All these costs would be lower on a better load factor—that is, if the annual output is increased without increasing the peak load, then each item will be divided by a greater number of k.w. hours to obtain the cost per k.w. hour.

Some of the principal factors affecting the cost of power are:—

(1) Steadiness and continuity of the demand for power (load factor).

(2) Security against interruption of supply, involving reserve plant and depending on type of plant.

(3) Cost and quality of fuel, including provision for storage, or annual capital charges on cost of dam and headworks (excluding power plant and buildings).

(4) Capital cost of plant and machinery, depending on type, overload capacity, etc.

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[1] Thos. Urquhart, Proc. Inst., M.E., Jan. 1899.
William Kent Power, Sept., 1902.
'Iron Age,' Nov 2, 1893.
I. R. Bibbins, Trans. A.I.E.E., vol. XXII, p. 767.
Liquid and Gaseous Fuels, Vivian B. Lewes, p. 137.
Public Water Supplies, Turneaure and Russell, p. 636.

(5) Cost of land, buildings and foundations, varying with type of plant, as affecting space, etc.

(6) Depreciation and repairs, varying with type of plant.

(7) Labour and superintendence, varying with type of plant.

(8) Length of transmission.

ITEMS IN COST OF STEAM POWER EXPRESSED AS A PERCENTAGE OF THE TOTAL COST.

Average results from several American plants.
Size, 3,000 to 5,000 k.w. Load factor, about 35 per cent.
Cost of fuel corrected to be equivalent to coal at $3.50 per ton.

—	Cost per K.W. hour.	Per cent of operating costs.	Per cent of total costs.
Operating costs—			
Fuel	·518	56·2	34·0
Wages	·169	18·3	11·1
Oil, water supplies	·042	4·6	2·8
Repairs and maintenance	·042	4·6	2·8
Management and office	·150	16.3	9·8
	·921	100·0	60·5
Annual capital charges—			
Cost per k.w installed $153			
Interest, 5 per cent; sinking fund, 3 per cent; depreciation, 4 per cent; insurance and taxes, 1 per cent; total, 13 per cent	·603	....	39·5
	1·524	....	100·0

Access to Pumping Station.

Two sites have been surveyed for a dam, and the route for a gravity pipe line to Regina approximately located from each.

The first site is due west from Boldenhurst, between townships 22 and 23, range 7, west of 3rd meridian (see Plate 38), and the nearest existing railroad station is Aiktow on the Outlook branch of the Canadian Pacific Railway, about 19 miles distant in an air line from the site.

The second site, in township 21, between ranges 7 and 8, west 3rd meridian, is about 15 miles south of the first and the nearest existing railroad station would be Tangragee, 3 miles east of Ernfold, on the main line of the Canadian Pacific Railway, about 23 miles distant in an air line.

It may be assumed that a branch railroad line would have to be built to the site of the pumping station, and this would probably have to be done at the expense of the proposed Water Commission.

Outside of any question of fuel for power, such a line would appear to be necessary for the conveyance of building materials, machinery for the initial plant and subsequent installations from time to time, supplies and stores, fuel for heating, etc., and practically necessary for the transportation of the engineers, manager and others, and it will therefore be a part of the cost of producing power at the proposed location.

Assume that the second location is selected, as it appears to give somewhat the shortest route for the pipe line.

No surveys have been made and only the roughest estimate of cost can be arrived at.

To the 23 miles by air line add 20 per cent for deviations to follow contour of the land, sidings, &c., and we have 28 miles. A full gauge line would need to be laid that could be used by the railroad companies.

Assume the cost at $15,000 per mile, complete with sidings, sheds, &c.

It may further be assumed that some form of motor car would have to be maintained for use on this line, and a man to operate it, to convey less than car-load lots of supplies, and carry passengers.

Take this car, with shed, &c., at $3,500, and allow for interest and depreciation say 20 per cent.

On the branch line the annual capital charges would not be less than: Interest, 5 per cent; sinking fund, 2 per cent; maintenance, 2 per cent; insurance and taxes, 1 per cent; total, 10 per cent.

The cost of this special line would then be approximately thus:—

First cost—	
Twenty-eight miles of track at $15,000	$420,000
Motor car, shed, &c.	3,500
	$423,500
Annual cost—	
Ten per cent on $420,000	$ 42,000
Twenty per cent on $3,500	700
Wages of one man	900
	$ 43,600
Incidentals, 10 per cent	4,360
	$ 47,960

Annual cost, say $48,000.

This is a considerable item to add to the annual costs, but, as it applies equally to whatever source of power is used, it has not been added to the estimates in any case.

Method of Comparison.

The comparison between different methods of producing power is, in this report, made on the basis that the total annual cost of producing power or pumping water is made up of:—

(1) Annual capital charges, i.e., interest, sinking fund, depreciation (according to type of plant), insurance, taxes, &c.

(2) Payments for water rights, water storage charges (for power), leases, &c., if any.

(3) Operating costs, including management, office, legal and all expenses not included elsewhere.

This covers every item in any way entering into the total cost, and represents the total annual expenditure, including proper provision for repaying capital and a depreciation and reserve fund to cover the difference between the probable life of the plant and the period of the loan, unforeseen expeditures (floods, lightning, &c.) and obsolescence of plant.

The system of power production which gives satisfactory assurance of capital safety and reliable operation and the lowest total annual expenditure (by the above method) should be the best financial and engineering proposition.

There is, however, another method of making these comparisons which may be referred to, as it is quite frequently used.

This consists of adding to the total capital expenditure the capitalized value of the estimated annual operating expenses, and comparing together the totals so obtained, calling the ratio between them the 'investment efficiency,' or some similar term.

This appears to be a purely theoretical way of looking at the matter and one not representing actual conditions.

The annual operating costs are not capital charges except possibly during the early stages or in the event of an unremunerative undertaking, and then only as to any deficiency. They are not taken out of capital nor can they be converted into capital (as profits could be), since costs must be spent as incurred.

Operating costs are, on the contrary, met as incurred out of revenue earned, they vary largely for the same size of plant according to the type of plant, the load factor and the efficiency of management, and have no fixed or definite relation to capital expenditure.

It would appear that whereas the first method may be suitably applied to compare the cost of different designs using the same source of power for the same purpose, the second method will be the most suitable for comparing the results to be obtained from different sources of power.

The sum of the annual capital charges, including proper provision for the future and of the operating costs, gives the total annual expenditure and liabilities and represents the actual conditions in practice.

The latter method has been used in all estimates and comparisons made in this report.

When, by a process of elimination, it has been indicated what source or sources of power appear most suitable for this particular case, the whole matter will have to be again studied from the point of view of location of sedimentation and filtering tanks, reservoirs, standpipes, etc., probably involving pumping in two or three stages and duplication of pumping plant. It may be pointed out that the capacity of the main pipe line is about 300,000,000 gallons.

It will be well, however, for the purpose of ascertaining the most suitable source of power, to make the comparison on the simplest possible basis, so long as the amount of power and size of units are approximately such as will be actually required.

It has been assumed, therefore, that a definite amount of water is to be taken direct from the river and elevated to a certain height by direct pumping, neglecting for the present considerations as to purification and reservoirs and putting all estimates on the basis of the same amount of work under the same condition.

It has also been assumed that there will be an initial installation of moderate size and that this will be gradually extended over a period of say twenty-five years to the full capacity for which rights of diversion of water have been applied for.

Discussions of the 'water required' and 'horse-power required' are given under those headings.

In the case of a water-power station the water could be pumped direct from the river.

In the case of a fuel-operated station the additional cost of cribs at the river, conduits between the river and the power station, and wells under the pumps, must be allowed for, in order to make a fair comparison.

In neither case, as above stated, is sedimentation or filtering taken into account, and if this is undertaken it will add an appreciable amount to the cost of the water delivered as given in the estimates.

QUANTITY OF WATER REQUIRED.

Quantity applied for.—In a letter of April 11, 1911, by the Commissioner of Public Health, Government of Saskatchewan, to the Minister of the Interior, it is stated that the Provincial Government had applied to the Commissioner of Irrigation for

authority to divert 100,000,000 gallons per day (185 c.f.s.) in the vicinity of township 25, range 5, west of 3rd meridian. This is in the neighbourhood of the Elbow.

This would supply, on the basis of an average demand of 100 gallons per capita per day, a population of 1,000,000.

Probable population.—As shown on page 104, it may be estimated that the population of the district to be first dealt with will be not less than 100,000 by January, 1915.

It does not appear probable that a population of 1,000,000 in the said area i.e., the Moosejaw-Regina-Weyburn district, will be reached for a good many years to come.

While it may be advisable to put in a pipe line of capacity to meet the probable demands for a number of years ahead, on account of the heavy proportion of the cost of trenching, etc., this does not apply to the pumping plant.

Pumping plant.—This can be put in in sections as required. An initial plant of reasonable size can be installed first and this may be added to from time to time by installing additional units as warranted by the demand. This will assist in keeping down the annual capital charges and reducing the burden on the undertaking during its early stages.

Initial installation.—From the above it would appear to offer ample margin to figure on an initial installation of pumping plant to supply 100 gallons per capita per day to a population of 200,000, i. e., 20,000,000 gallons per day or 37 cubic feet per second.

The estimates which follow are therefore based on an initial installation of 20,000,000 gallons per day, with an average consumption of 75 per cent of this, or 15,000,000 gallons per day.

They are then extended to show the effect of a larger output on the cost of pumping, up to the full amount of 100,000,000 gallons per day.

HORSE-POWER REQUIRED.

It is desired to compare the cost of power from coal, oil, etc., with the cost of water-power, on as equitable a basis as possible.

It will therefore be first assumed that the power is to be developed or used at the same point as is proposed for the hydraulic plant, and that the water will be pumped to the intake for the proposed gravity pipe line.

If the power used is other than water-power there would be no dam required, and the lift would therefore be some 37 feet higher than that taken in the Annual Report of the Department of the Interior, 1912, page 223.

Taking the data from the said report, we have:—

Intake to gravity pipe at Boldenhurst (elevation sufficient to give a supply without pressure at the elevation of the C.P.R. rails at Regina)	1,951·00
Natural low water	1,653·00
	298·00
Allow for friction, etc., 10 per cent	29·80
	327·80

Total head, say, 328 feet.

Initial installation.

Quantity—

Cubic feet per second	37
Gallons per day	20,000,000
Gallons per minute	13,900

Head, including 10 per cent for pipe friction, 328 feet.

$$\text{Theoretic horse-power} = \frac{\text{weight x lift}}{550}$$

$$\frac{37 \text{ c. f. s. x } 62{\cdot}355 \text{ lbs. x } 328 \text{ feet}}{550} = 1{,}375.$$

Complete installation.

Quantity—

Imperial gallons per 24 hours. 100,000,000
Imperial gallons per minute. 69,500
Cubic feet per second. 185

Head, including 10 per cent for friction, 328 feet.

$$\text{Theoretic horse-power } \frac{185 \text{ c. f. s. x } 62{\cdot}355 \text{ x } 328}{550} = 6{,}875.$$

CAPACITY OF PLANT.

Initial Installation.—From the foregoing it appears advisable to instal plant for an initial capacity of 20,000,000 Imperial gallons per day. To provide reserve, two such units must be installed.

Future Additions.—Units should be added as required in sizes to give a number of sets and thus provide ample reserve. The ultimate installation should be such that if one of the units is laid off, or out of service, the full normal capacity remains. After the initial installation, further units might be of about 30,000,000 gallons capacity each.

Ultimate Capacity.—The number of units and total capacity of the complete installation would then be:—

Installation.	Pumping units.	Capacity per day in Millions of gallons.		Reserve.
	Nos.	Each.	Total.	Per cent.
Initial	1 and 2.	20,000,000	40,000,000	100
Extensions.	3, 4 and 5.	30,000,000	90,000,000	
Complete.	5 Units.	. . . .	130,000,000	30

Output.—It is assumed (as stated under 'Quantity of water required,') that the average load will be 75 per cent of full normal load, and that the plant will operate 24 hours a day, 365 days a year.

POWER PLANT AT THE RIVER.

There must be a pumping station at the river, and if the power plant can be combined with this there will be but one building, plant and staff instead of two. Furthermore, the power can then be applied direct and there will be no losses due to transformation and transmission of energy.

The direct application of fuel power at the river is therefore one of the first alternatives to be considered and it will be seen that estimates have been prepared for the following methods:—

High duty steam pumping engines.
Steam turbine driven centrifugal pumps.
Natural gas under steam boilers.
Oil engine plant.

It should be noted that the water of the South Saskatchewan river is excellent for steam boiler purposes. (See 'Water of the South Saskatchewan river, page 114.)

COST OF COAL DELIVERED AT THE RIVER.

One of the first alternatives to water-power due to be considered is the use of coal at the pumping station, enabling the use of direct acting high duty pumping engines giving high fuel economy, or steam turbine driven centrifugal pumps giving low first cost, since these would avoid all transformation and transmission costs and losses.

The location of the proposed water-power site is described under 'Access to pumping station, page 106.

If a gravity pipe line is used, then a fuel-operated pumping station would need to be located at or near the same spot in order to pump into the intake of the said gravity pipe line.

The three principal established sources of coal to consider are: Estevan and The Consumer's Coal Company (which see) for lignite, and the Crowsnest district for bituminous.

For the latter, a representative coal similar to that now used by the Electric Light Department at Moosejaw, and stated to be satisfactory, will be considered.

It is not proposed to make any general discussion of the quality and performance of western coals and lignites, as this has recently been very fully investigated by the Department of Mines, Ottawa, and is dealt with in their recent reports. (1)

Only the three sources of coal above mentioned will be used for comparisons and estimates.

The Estevan lignites are well known and have established their suitability for both steam raising and producer gas making.

A short account of the Consumer's Coal Company's mine and product is given under that heading. It appears to be a fairly good lignite, similar to that from Estevan, and would have the advantage of over 100 miles shorter haul, saving about 95 cents per ton on freight. This mine is situated about 8 miles from Expanse and has not yet secured a railway connection. (Nov., 1912.)

The Crowsnest coals are superior to the above, but the cost delivered is higher.

The approximate costs and values for steam raising are given in the following table, compiled from official sources and tests:—

Number.	Source.	Approx. Distance in Miles.	Cost. "Run of Mine" Delivered.	Moisture.	Ash.	B.T.U. Dry Coal.	Water Evaporated per pound Coal from and at 212° F.	Pounds of Water Evaporated for One Cent.
			$ cts.	Per cent.	Per cent.			
1	Coleman Crowsnest Bituminous..........	423	5 65	0·8	19·8	11,720	7·17	25·38
2	Estevan—Lignite.....	237	3 90	28·6	8·1	10,690	3·91	20·05
3	Consumer's Coal Co.—Lignite.........	135	3 05	32·4	7·9	10,000	3·66	24·00

1 An investigation of the coals of Canada, vols. 1 and 2, 1912.

It will be seen that for the purpose of steam raising at the particular spot under consideration, the Crowsnest coal would appear to give the best value for the money, and to be the most suitable to figure on for that purpose.

However, the apparent values are so close that it could only be determined by actual test under working conditions which would prove the cheapest in practice.

The above comparisons have no bearing on the cost of producing power at the pit mouth, which will be considered separately.

Coals 1 and 2 were tested under the superintendence of the Mines Department, Ottawa, under the same conditions and in the same boiler and furnace.

Coal 3 was separately tested as described under the head of 'Consumer's Coal Company,' but the evaporation is estimated and not the result of test.

It is probable that both the lignites would give considerably better results if burnt in larger boilers with special furnaces.

It is also probable that better test results could be obtained for the Crowsnest coal, with a larger boiler, an economizer, etc., but for an all-the-year-round performance which includes losses due to standby as reserve, blowing down and banking boilers, weathering by storage, etc., it would probably not be safe to assume a much better figure.

Freight Rates.—In regard to freight rates as affecting the total cost of coal, it may be anticipated that these are more likely to be decreased than increased.

In a report of the Western Freight Rates Case hearing before the Railway Commission (1) it is stated as follows: Mr. M. K. Cowan, K.C., counsel for Saskatchewan and Alberta, then took up the rates on coal from Estevan to other Canadian Pacific Railway stations in Saskatchewan as compared with the Great Northern Railway, Northern Pacific and Soo line rates in North Dakota for similar distances. His exhibit showed that the Saskatchewan rates were from 72 to 121 per cent higher than the American ones.

It was also shown by the Commissioner of the Board of Trade of Saskatoon, (2) that whereas the coal freight rate from Edmonto to Saskatoon, involving a drop of 614 feet, was 0·828 cents per ton mile, the rate from Port Arthur to Saskatoon involving a rise of 1,574 feet, was 0·531 cents.

The rate from Estevan to Elbow, as given recently for the purpose of this report by the Canadian Pacific Railway, is equivalent to 0·93 cents per ton mile.

The Grand Trunk Pacific railway have under construction lines from the Estevan district to Moosejaw via Regina and from Moosejaw to Elbow, which may also have some effect on the freight rates.

In this connection the secretary-treasurer of the Estevan Board of Trade recently stated (3) that when the new Grand Trunk Pacific line between Estevan and Regina is in operation it will be possible to lay down lignite in that city at approximately $1.80 per ton, the cost of mining being in the neighbourhood of 65 to 80 cents.

It would therefore appear desirable, when the matter is ripe for decision, to revise the estimates hereafter given in accord with the latest freight rates and quotations for coal and lignite.

The Consumer's Coal Company.

The nearest developed coal mine to the river is that of the Consumer's Coal Company, situated on the Lake of the Rivers, about 35 miles due south of Moosejaw (see Plate 38). The head office of this company is in Moosejaw, and the president is Mr. John E. Chisholm, LL.B.

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(1) Ottawa *Citizen*, January 10, 1913.
(2) Saskatoon *Daily Star*, November 18, 1912.
(3) Regina *Evening Leader*, November 26, 1912.

Distance.—This mine is distant in an air line from Elbow less than 100 miles as against about 220 miles to the coal fields near Estevan, which would be a large consideration in the cost of transmitting electric power to the river. The distance via Moosejaw and the Canadian Pacific Railway line to Elbow would be about 115 miles, but this route would give an opportunity to supply light and power to intermediate towns and would thereby reduce the cost of transmitting power to the pumping station.

Quantity.—This property was inspected by Mr. D. B. Dowling, B. Sc., of the Geological Survey, Department of Mines, in June, 1912. He said: 'There is an eight-foot seam and an estimated quantity of 11,000 tons per acre . . . it would be a good gas producer as well as fuel for cheap power . . . it will double the former estimate (18 million tons) of Saskatchewan's coal supply . . . With the coal there in such large quantities, the proper thing to do is to put the city (Moosejaw) power plant right there . . . Much of the coal waste could be utilized in generating power, giving the city a remarkable advantage for cheap current.'

Quality.—A shipment of coal was submitted by the company to the Mines Department, Ottawa, for a test of its qualities in a gas producer, and a report was made under date of July 12, 1912.

The conclusions from this report are that:—

The fuel burned uniformly without the formation of troublesome clinker.

The gas generated was tar-free and heating value satisfactory.

The engine valves were found to be exceptionally clean after a run of forty hours.

The lignite may be pronounced an excellent fuel for the production of power when utilized in a producer gas plant as it arrives from the mine without further treatment. The tendency to disintegrate does not in any way interfere with its operation.

The approximate analysis by fast coking was:—

	Per Cent.
Moisture	32·42
Volatile combustible matter	28·29
Fixed carbon	31·32
Ash	7·97
	100·00
Coke	39·29

Calorific value of moisture free fuel, 10,000 B.T.U. per pound.

Average effective calorific value of gas per cubic foot, 115 B.T.U.

The report also states that the quantity of coal sent was insufficient to determine the volume of gas generated per ton of fuel, so that this and the thermal efficiency were not determined, but that the indications were that these would have been satisfactory.

In a report to the company (mainly concerning their clay deposits) by Dr. G. A. Charlton, provincial analyst, Regina, dated October 22, 1912, it is stated that this lignite in appearance and texture closely resembles the coal now being mined in the vicinity of Edmonton.

Development and Price.—The company claim that they control 1,500 acres of coal land, that they have so far confined themselves to development work, producing ten to thirty-five tons per day for which they have found a ready market, as fast as produced, to railroad camps, farmers, etc., that the coal is very easy to mine and that the output can be easily increased to any desired extent.

They also stated (letter of November 19, 1912) that they would be prepared to supply screenings consisting of all under 2-inch and free from slate or clay, at 95

cents per ton, or run of the mine at $1.50, at the pit mouth, or either grade loaded on cars at 5 cents to 10 cents per ton extra.

A visit to the mine on November 21, 1912, showed considerable development work. A nearly level tunnel has been driven into the side hill for about 250 feet with an extension north of about 60 feet. Off these there are several chambers and cross cuts. It appears to be a solid seam of fairly good lignite and is being mined so that the product is practically all clear coal, comparatively hard and solid and coming away in large lumps. The lignite, as burnt under the steam boiler and in the house furnace appeared to be clean and free burning, free from smoke or soot and giving a hot flaming fire.

Railway connection.—At the present time the company have no railway connection (November, 1912). The C. P. R. have a line in operation to Expanse, eight or nine miles northwest of the mine, and the C. N. R. are constructing (now graded) a line which passes about three miles to the north of the mine. (See Plate 38.)

THE WATER OF THE SOUTH SASKATCHEWAN RIVER.

Suitability for steam boilers.—The C.P.R. Company have a steam-operated pumping station on the river at Elbow and their engineers state that they consider this water 'excellent for steam boilers, that it requires no treatment and gives no trouble except from being muddy at times.'

The following is a copy of the C.P.R. Company's analysis and record of this water:—

OUTLOOK SUBDIVISION.—WATER SUPPLIES.

Name of water station, Elbow.
Supply, South Saskatchewan river.

Analysis in parts per 100,000—	
Cal. Carb	8·87
Cal. Sulph	2·21
Mag. Carb	....
Mag. Sulph	2·27
Sod. Chlor	11·11
Sod. Sulph	3·36
Pot. Chlor	0·96
Si. O_2	1·20
Iron and alumina	0·15
Scale forming matter—	
Parts, per 100,000	14·7
Pounds per 1,000 gallons	1·5

Remarks: Good water.

The report of Mr. Walter J. Francis, previously referred to, says:—

> 'Coming as it does from glacier and mountain streams, it is well suited for domestic, manufacturing and municipal purposes. The water has the turbidity peculiar to all such streams at this time of year (May). Fortunately, its turbidity is easily removed by settlement and coagulation.
>
> 'While the water in its present state is probably sufficiently pure to be used untreated, the growth and development of the country and the consequent increased pollution of the river, make purification a future necessity which might be even now advantageously adopted.'

GAS TURBINES.

Gas turbines are sometimes inquired about as a supposed coming form of prime mover.

There does not at present appear to be any probability of these developing into a commercial or practical apparatus in the near future.

A recent paper by Dugald Clerk, D.Sc., F.R.S., a well-known authority, read before sec. G. of the British Association at Dundee, September 9, 1912 (1) gives an account of past experiments and the present position of this type of engine.

The following is a brief summary of the conclusions reached:—

> 'Many attempts have been made to produce a commercial gas-turbine. So far no attempt has succeeded; the practical difficulties have proved to be too serious. . . . . .
>
> 'Recently the explosion type has been studied by Mr. Hans Holzwarth, who has built a gas turbine of a rated power of 1,000 horse-power. . . Many practical difficulties were found, but ultimately the turbine was operated by producer gas made from coke. . . . So far as I understand Mr. Holzwarth's experiments the highest power actually obtained was about 160 brake horse-power. . . . . From these experiments Mr. Holzwarth came to the conclusions that the successive explosions interfered with each other. . . . The theory of the Holzwarth machine does not appear to me to permit more than a 10 per cent heat conversion. So far as I understand Mr. Holzwarth's results, his actual conversion is much less than this. . . . .
>
> 'The existing internal combustion engines are quite satisfactory for small and moderate power units; but the weight increases so rapidly with increase of cylinder diameter that large units, such as 20,000 horse-power per shaft, easily attained by the steam turbine, have proved quite impossible for the reciprocating gas engine.
>
> 'In order to apply internal combustion for the purpose of such large units, it appears to me to be necessary to dispense with the cylinder, piston and crank. I fear that this cannot be done on the lines of either constant pressure or explosion turbines here shortly discussed.'

On the other hand, it is stated by Mr. R. A. Fernald in a recent paper (2) that:—

> 'Results are soon to be expected from the more recent investigations and tests relating to gas turbines. Some of the types are believed to be based on correct principles, so that after a satisfactory rotary air compressor has been designed, rapid progress in the development of this prime mover may be expected.'

In his inaugural address as president of the Institution of Electrical Engineers, London, England, in November, 1910, Mr. S. Z. de Ferranti said, in reference to coal conservation:—

> 'In the future we have to look towards two other means of conversion—the gas-turbine—driven electric generator and the production of electricity in some more direct way from the coal, but these two means of conversion, although capable of giving the most efficient results, are so much in the distance, that they are quite beyond our present consideration.'

INTERNAL COMBUSTION PUMPS.

Of this type of pump, the furthest developed appears to be the 'Humphrey,' as developed by the Pump and Power Company, Limited, 28 Victoria street, London, England. This is not only a new design but embodies an entirely new principle, and while not yet a fully demonstrated success for all classes of pumping, its performance to date has been so promising that it is thought to be worth careful consideration and inquiry.

1 Reprinted in *Engineering*, London, September 13, 1912.
2 Technical Paper 9, U.S.A., Bureau of Mines, 1912.

In addition to a study of the available information on the subject, this branch caused one of its engineers, Mr. Alfred M. Beale, B.Sc., to visit and report upon plants in operation and under construction in England, and the information so obtained is incorporated in the following:—

The pump is of extreme simplicity—in Mr. Beale's words 'the most striking thing about the whole plant is that there is so little to see,'—nevertheless, a sectional drawing and lettered description is essential to a clear understanding of its operation, on account of the new principle involved.

This is, therefore, given first and is followed by a brief discussion of the difficulties that will most readily occur to readers. A description of the present stage of development is then given and a bibliography is added to assist those interested in obtaining more detailed information.

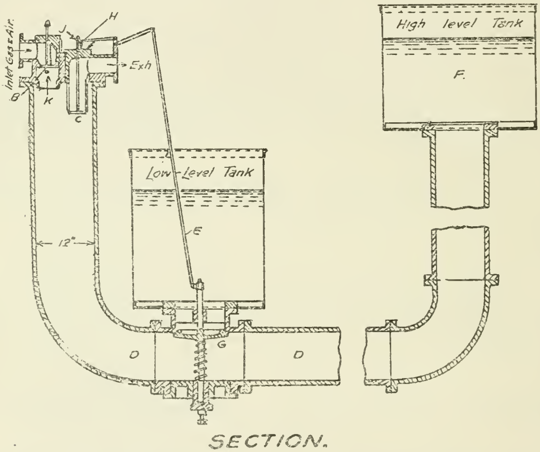

FIG. 1. Humphrey Internal Combustion Pump. First experimental four cycle pump.

In this internal combustion pump the explosion of the charge of gas takes place in direct contact with the column of water, which acts as a water piston. A horizontal pipe forms the pump and is connected at one end to a combustion chamber and at the other to an open water tower. The water is able to surge or oscillate freely backwards and forwards after an explosion and this surging column of water fulfils all the functions of a piston and pump plunger even to controlling the valves for water, gas and air, and exhaust.

The following description of the simplest form, together with the accompanying cut, Fig. 1, is taken from Mr. Humphrey's paper before the institution of Mechanical Engineers, London, November, 1909.

> 'The pump consists essentially of a combustion chamber A, fitted with an intake valve B for combustible mixture, and an exhaust valve C for burnt products. A pipe D connects the bottom of the combustion chamber to a low level tank E and to a high level tank F, and between this pipe and the former

there is a water valve G. The inlet valve B is normally kept shut by a spring, but the exhaust valve C has no spring to hold it up and falls by its own weight when the pawl H is removed from under a collar J fastened on the exhaust valve stem. This pawl is operated from the water valve G in the simple manner shown, so that when the water valve opens it releases the exhaust valve.

'Suppose all the valves shut and a compressed combustible charge to exist in the top of the combustion chamber. The rest of the chamber and the pipe are full of water. Explosion occurs at a sparking plug K, and the increase of pressure drives the water downwards in the chamber and forces the column of water contained in the pipe to move towards the high level tank so that a quantity of water is discharged into this tank. From the moment when ignition occurs to the time when expansion reaches a pressure equivalent to the static head of water in the high level tank, the excess pressure in the combustion chamber has been increasing the velocity of flow towards the high level tank, so that at the end of this period the column of water has a considerable velocity. The kinetic energy thus acquired causes the water to continue to flow in the same direction, until the pressure on the underside of the water valve is less than that above the water valve, and the difference of pressure causes this valve to open. This occurs when the products of combustion have expanded to about atmospheric pressure. The opening of the water valve releases the exhaust valve, and now water from the low level tank flows past the water valve partly to follow the column of water still moving towards the high level tank and partly to flow into the combustion chamber to expel some of the exhaust gases.

'There is, of course, a tendency for the water to rise in the chamber to the same level as the water in the low level tank, but usually a little before this level is quite reached the kinetic energy of the moving column has been expended in forcing more water into the high level tank, and the column has therefore come to rest. At this point of the cycle the spring on the water valve quietly closes this valve, and is assisted by the water now trying to flow back from the high level tank to the chamber. It cannot flow back far, because there is already a considerable quantity of water in the chamber, and as the column rises further it reaches the exhaust valve and striking against it, shuts it by impact, The exhaust valve is immediately locked shut, by the pawl shown engaging under the collar of the valve stem, and now that there is no longer any outlet for the small quantity of burnt products which remain, they are imprisoned in the top of the chamber and suffer compression as the water continues to rise, until the energy thus stored in the compressed elastic cushion is equivalent to the energy given out by the falling water. Thus the elastic cushion serves to bring the column of water again to rest, and as the compression pressure considerably exceeds the static head of the water column, a reverse flow is set up while this cushion expands again. If there were no friction losses the water column would be pushed back by the cushion to the same point as that from which it started, namely, to a level in the combustion chamber a little below the level of the water in the low level tank, but it actually does not move quite so far. However, when the water passes the level of the exhaust valve the elastic cushion is again at atmospheric pressure, and the further descent of the water in the combustion chamber tends to create a vacuum, but the inlet valve is only held shut by a light spring, and can therefore readily open to admit a fresh combustible charge during the rest of the descent, and until the water column is once more at rest. The state of affairs now reached is of course still unstable, because of the unbalanced pressure due to the head in the high level tank, and this head produces a second return of the column, so that the water ascends in the combustion chamber and compresses the fresh combustible charge. The

explosion of the charge by means of the ignition plug now starts a fresh cycle. The operation of the apparatus is so simple that when an actual apparatus on these lines was first tried it ran steadily at the very first attempt.'

Several other forms have been developed in addition to that above described, for suction lifts, higher heads, etc. In the larger pumps there are a large number of small water valves instead of one large valve.

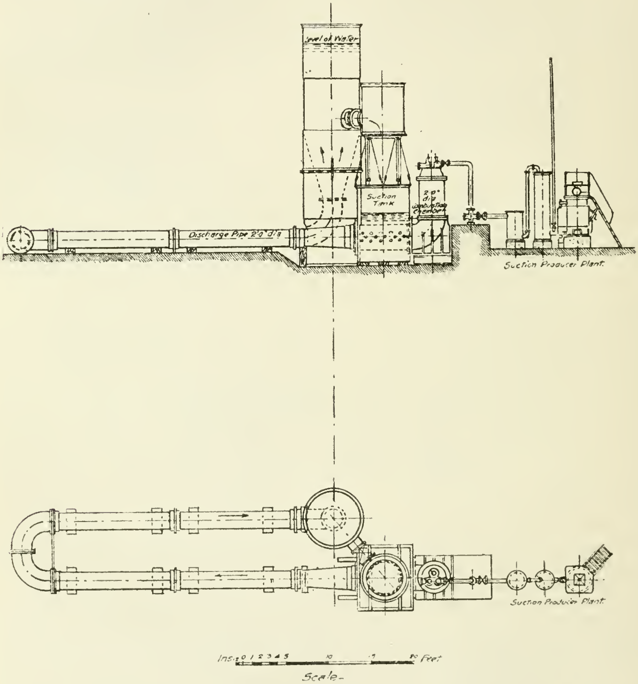

FIG. 2. The Humphrey pump. General arrangement of plant at the Brussels International Exhibition.

Figure 2 shows the general arrangement of the plant exhibited at the Brussels International Exhibition, as described in *Engineering*, London, July 22, 1910. This pump, giving 36 horse-power on producer gas, consumed less than one pound of anthracite coal per actual water horse-power hour, and obtained the two 'highest possible' awards.

Accompanying photos show the combustion chamber of a unit of 40,000,000 gallons per day capacity, the suction valve box and the discharge from one 40-million-gallon pump at the Chingford reservoir (described below).

Mr. Humphrey's paper, 'An Internal Combustion Pump,' read before the Institution of Mechanical Engineers, London, in November, 1909, gives a mass of detailed information on design and comparative costs of operation. It also produced a very full discussion by prominent engineers and it may be of interest to give some brief extracts from this as representing the views of those who presumably have no material interest in the matter.

Dr. W. Cawthorne Unwin, referring to the tests carried out on this pump, said:—

'Once started it not only worked absolutely without the slightest hitch, but it had a flexibility which enabled one to play tricks with it—to alter the lift and to alter other conditions of working, and yet the pump seemed to take no notice of them at all.'

Mr. W. B. Bryan, chief engineer, Metropolitan Water Board, said that:—

'It appeared to him that for low lifts the pump had a magnificent field before it.'

Prof. Vernon C. Boys said:—

'When all was cold and at rest one touch of the button instantaneously started the machine going at full speed. . . when made larger the difficulties instead of being greater ought to be less.'

Mr. Alfred Chatterton, engineer, Irrigation Department, Government of India, said:—

'He would like to compare these results with those obtained at the irriga-'tion pumping station at Divi in the Kistna district of the Madras presi-'dency. There eight Diesel engines of 160 B.H.P., driving 39-inch centri-'fugal pumps, lifted water over a range of 14 feet . . . it was found 'that under the most favourable conditions 13,000 B.T.U. were required per 'W.H.P. hour, and that when the pumps were working at two-thirds the most 'efficient load, the thermal units expended rose to 17,000, which was a great 'contrast to what had been obtained at Dudley Port (with Humphrey pumps). 'He thought that the Divi pumping station represented the highest limit of 'efficiency so far attained with internal combustion engines and centrifugal 'pumps, but the fuel used was petroleum residues which cost about £3 per ton 'delivered (about 5·76 cents per gallon). Gaseous fuel of equivalent value, 'whether from wood or coal, could certainly be manufactured at Divi for 'less than half that price, and with the gas pump it would be possible to 'lift water at about one-third of the present cost, as there would also be a very 'considerable saving in interest on capital outlay, cost of repairs and stores, 'and in salaries and wages.'

Mr. Ewart C. Amos said:—

' . . . These and other equally obvious reasons made it evident that 'the actual cost of raising water would be considerably less with a 'Humphrey pump than with steam pumps, and further, the efficiency would 'be maintained for a much longer period and at less cost than with any other 'form of pump at present known.'

The above quotations are favourable, but various questions were asked as to space occupied, corrosion of the inside of the pump and piping from the products of combustion of the gas, tarry or oily appearance on the surface of the water, contamination of the water for drinking purposes, etc., to which Mr. Humphrey replied in effect as follows:—

The space occupied by triple expansion high duty pumping engines is from six to nine times, or more, than that occupied by Humphrey pumps.

With reference to tarry or oily appearance on the surface of the water,—'looking at water which had been pumped around hundreds of times no trace 'of any tar was observable in the reservoir—he had a certificate from Dr. 'Hertz, of London, showing that there was no SO_2 in the water pumped 100 'times.'

Mr. Bryan, chief engineer, Metropolitan Water Board, was invited to arrange a test which should be conclusive as regards contamination of drinking water. The test was carried out and the water analyzed by the public analyst of the County Borough, who reported:—

'From these results I am of opinion that the water is not contaminated 'by tar or sulphurous acid.'

The test and analysis are given in detail in the paper above referred to.

In respect to corrosion of pipes:—

'Water which had been circulated many hundreds of times through the 'pumps was found to have no deleterious effects . . . iron pipes which 'had been in use three years showed no evidence of corrosive action . . .'

Re vibration:—

'The water valves of the Humphrey pump worked so smoothly and 'quietly that it took a trained ear, placed against suction tank, to detect 'their operation at all, and they had never given any trouble.

'There were types of the pump suitable for working with a suction lift ' . . . if the pump was to be used for power production in such large 'units the arrangement for delivering water at high pressure would probably 'be adopted and in such case the compression pressure was entirely under 'control and could be made as high as one pleased . . . the problem of 'constructing a 1,000 horse-power unit should not involve any insuperable 'engineering difficulties . . . . no part of the pump chamber got hot 'enough to make it unpleasant to hold one's hand on any part.'

Present development.

Coming now to the present stage of development, a brief description may be given of the large units designed for city water supply in London, England, and for drainage operations in Egypt.

The principal plant in England is that of the Metropolitan Water Board, London, who have installed four Humphrey pumps of a capacity of 40,000,000 gallons each per day and one of 20,000,000 gallons at their new Chingford reservoir. The combined output of these pumps is 180 millon gallons per day, or about two-thirds of the average daily supply of the city of London. The lift is 25 to 30 feet, so that a 40,000,000 gallon unit develops about 252 water horse-power.

The Committee of the Metropolitan Water Board, after a thorough investigation which included gas engines, Diesel oil engines and electric power, unanimously reported in favour of the adoption of the Humphrey pump, and their report showed a saving in first cost of $92,000 on the complete installation, including buildings and foundations, as compared with triple expansion engines and centrifugal pumps at 350 R.P.M.

The combustion chambers and valve boxes of the 40 million gallon units are 7 feet in diameter and the bends connecting them with the horizontal pipe weigh 22 tons each.

The fuel is producer gas from anthracite coal at about $5.55 per ton of 2,000 pounds, the guaranteed consumption is 1·1 pounds of coal per actual W.H.P. hour and the guaranteed fuel cost is about 0·04 cents per 1,000 gallons delivered into the reservoir, but it is expected that the actual figure will be about 0·032 cents.

The pump designed for the Egyptian Government at the request of the consulting engineer to the Public Works Department is to deliver 100,000,000 gallons per day with a lift of 19 feet (400 W.H.P.) for drainage purposes. It is understood this pump has now been shipped.

Summary.

It will be seen from the above that these pumps have sufficiently demonstrated their qualities to be chosen for large and important work in competition with steam, gas and oil engines, but that the result of actual operating performance and working costs on a large scale are not yet available. The official tests by the Metropolitan Water Board will probably have been carried out before this report appears.

Also it will be noticed that both the installations described are for low lifts, 19 to 30 feet and for comparatively small horse-power (250 to 400 W.H.P.), for though the volume of water is large the lift is small.

The lift required from the Saskatchewan river is about 300 feet and convenient sizes of units would be about 1,400 and 2,000 water horse-power. The size of unit, however, could be further sub-divided and the lift could be done in more than one stage, if the advantages of this type of pump made this course desirable.

The generally expressed opinion is that this is essentially a low lift pump for dealing with large quantities of water.

The makers, however, say that higher lifts have been developed in experiments up to 200 feet, this being the limit the experimental conditions allowed for, that the pump then showed no signs of having attained its limit and that the results were as satisfactory as for low lifts.

Mr. Humphrey has stated:—(1)

> 'Coming now to high lift pumps, any Humphrey pump . . . may be converted into a high lift pump by means of an air vessel fitted with valves and called an "intensifier."'

In respect to larger units, they would have to feel their way to the special designs, but no difficulty was experienced in passing from 2 feet to 6 feet diameter, and the larger pump started without a hitch. The larger the pump the higher the efficiency. For high lifts it might be necessary to use 500 W.H.P. units, but this is suggested by present practice and larger units may prove to be possible and economical.

The makers claim that the pump will deliver water under any conditions that other pumps will and that any explosive mixture will supply the motive power; that the only parts liable to require attention are the valves and seatings, on which the wear and tear is not large and which can be quickly replaced; that the lubricating oil is negligible in amount, and that the plant can be operated by 'handy' men with one mechanic in charge.

Cost.—At the present stage of development and with the data so far available, it is felt that a detailed estimate of cost would not be sufficiently reliable to be of value.

However, from a careful consideration of such data and prices as have been obtained it may be said, as an indication of the possibilities, that:

(1) It appears that the cost of Humphrey pumps erected in Saskatchewan and complete with producer gas plant would be approximately the same as that for steam turbine plant. (See summary on pages 128 and 129.)

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[1] 'Humphrey Pumps and Compressors,' the Manchester Association of Engineers, Nov., 1910.

(2) It appears that the total annual cost, or the cost per 1,000 gallons pumped, should be at least 25 per cent less than with steam or water-power during the initial stages, but that water-power might be about 15 per cent cheaper on the complete installation with full output.

(3.) There is no doubt that the performance and prospects of the Humphrey pump are sufficiently established to call for a full investigation of this alternative before any considerable expenditure is incurred.

INTERNAL COMBUSTION PUMPS.

Bibliography.

Among the most recent descriptions are:—

'Large Humphrey pumps for Chingford and Egypt.' This is a detailed description, with photos and sectional drawings. *Engineering,* London, December 13, 1912.

'London Water Supply. The Chingford Reservoir.' The *Times Engineering Supplement,* May 29, 1912.

'The New Reservoir at Chingford.' *The Engineer,* London, March 14, 1913, and two following issues.

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'The Humphrey Internal Combustion Pump.' *Practical Engineer,* August 4, 1911.

'Humphrey Internal Combustion Pump.' By Edward N. Trump, *American Machinist,* January 5, 1911.

'The Babcock Two Cycle Internal Combustion Pump.' *Engineering,* London, May 5 ,1911.

'Technical Paper 9,' U. S. Bureau of Mines, 1912.

SUMMARY OF ALTERNATIVE SOURCES OF POWER.

The principal subdivision is:—

(1) Water-power plant located on the South Saskatchewan river near the Elbow.

(2) Fuel-operated plants located at the river or at a distant point with electric transmission.

Fuel Plants.

In considering coal-operated plants it must not be presumed that it is necessarily cheaper to generate power on the coal field and transmit electrically to the pumping station rather than convey coal by rail. In this case transmission involves two separate buildings and plant (power plant and pumping plant) and two separate staffs to operate them, i. e., there must be a power station at the mine with boilers or gas producers, engines, generators, switchboards and transformers, a more or less lengthy transmission line, and a pumping station with transformers, motors and pumps. In other words, the additional cost of installing and operating the additional plant, together with losses in conversion and transmission, must be set against the cost of conveying coal by rail. (See page 170.)

In the following list of possible sources of fuel power, some of the alternatives are strictly practical and are considered and estimated for in detail in the following pages; others are merely suggestive of possibilities that may be worthy of further examination.

(1) Steam plant—

A. Located at the coal mine, with electric transmission and motor-driven pumps, involving two separate plants and staffs.

B. Located at the river, coal delivered by rail, enabling the use of high duty pumping engines, giving direct application of the power and avoiding cost of extra plant, staff and transmission.

C. Ditto, with steam turbines and centrifugal pumps, giving low capital cost.

D. The plant in B or C, with the boilers fired with natural or producer gas, or oil.

(2) Producer gas plant—

A. Located on a more or less distant coal field, with electric transmission to the river and motor-driven centrifugal pumps; involves two separate plants and staffs, and losses in conversion and transmission.

B. Located at the river, coal delivered by rail; saving additional buildings, plant, staff, losses, etc.

C. Located on a nearby coal field, if available, transmitted to the river by pipe, and used in gas engines or under steam boilers.

(3) Purchased power supplied, ready for use, to an electrically-operated pumping station supplied and worked by the Water Board. (See page 157.)

(4) Oil fuel—

A. Diesel oil engines, located at the river, direct connected to pumps and operated by imported fuel oil.

B. Ditto, operated by oil produced from western shales.

C. Steam boilers fired with imported fuel oil or shale oil.

(5) Natural gas (see page 134.)

A. In gas engines.

B. Under steam boilers.

C. In internal combustion pumps.

(6) Internal combustion pumps, of the Humphrey or other type, located at the river and operated with—

A. Natural gas.

B. Producer gas.

C. Oil gas, produced from crude petroleum or shale oil.

Many other combinations can be made with the above, but those given are believed to cover the principal divisions.

With respect to the high duty pumping engines and to some extent also with the steam turbine equipment, very different results are obtained according to the 'duty' or foot pounds of work per pound of steam. The higher the duty the greater the refinements necessary to obtain the increased economy, and therefore the greater the first cost, but the smaller the consumption of fuel. If the undertaking is proceeded with it would be worth while to work out several estimates of first cost and coal consumption for different duties, in order to ascertain the minimum first cost that will secure the best result with these types of plant.

It is believed, however, that the estimates which follow will be sufficient to give a fairly close idea of the results that can be obtained with the proved sources of power.

It may be pointed out that the exact cost of power will have but a comparatively small influence on the total cost of water delivered to the consumer, as shown by the table on page 175.

SUMMARY OF BASIS OF ESTIMATES.

Capital costs for plant are based on recent quotations for this or similar plant, and special care has been taken to put all estimates on as equal a basis as possible.

The figure for cost of cribs, conduits and wells, while based on such work in a similar location in the west, is not reliable, for the cost cannot be determined with any accuracy without a survey, and no survey has been made for the purpose, but it is believed that the figure should be ample. In any case it is taken at the same figure in all estimates and cannot seriously affect the comparative results as a whole.

Annual capital charges on fuel-operated plant are taken as follows:—Interest, 5 per cent; sinking fund, 3 per cent; overall depreciation, including buildings, 2 per cent; insurance and taxes, 1 per cent; total, 11 per cent; 11 per cent is charged on plant and buildings and 8 per cent on the amount borrowed to cover engineering and contingencies and interest during construction.

Engineering and Contingencies.—It will be noted that 15 per cent has been allowed for these items for the initial installation and only 7½ per cent for the complete installation. It is presumed that practically all the surveying and designing work will be done in connection with the initial installation and that subsequent additions will be practically a duplication of existing plant, involving but little expense for engineering and contingencies.

Buildings.—Steel framed concrete, of best construction

Labour.—Three shifts, never less than two men in engine room and two men in boiler house, one first-class mechanic with assistant according to size of plant, etc.

Fuel.—The calorific value and evaporative power assumed for the different coals are based on the values given by the Mines Department, Ottawa ([1]) or other specified sources. The cost of coal and of freight on coal are based on actual prices obtained from official sources at the time the report was in preparation.

The cost of natural gas and oil is dealt with in the chapters relating thereto.

Steam Plant.—Suitability of the water is dealt with under 'The Water of the South Saskatchewan River.' Boiler efficiency, in view of fairly large units, soft water, and steady operation is taken at 75 per cent, with economizers and superheaters. Superheat 150° F. Steam pressure, 175 pounds.

Capacity of Plant.—Initial installation, 20,000,000 gallons per day. Complete installation, 100,000,000 gallons per day.

Output.—Seventy-five per cent of full normal rated load, that is, of the above capacity.

Reserve.—Initial installation, 100 per cent (two equal units, one as spare). Complete installation, 30 per cent (one 30,000,000 gallon spare).

Head, including 10 per cent friction in pipes to delivery to gravity pipe line, 328 feet.

Water Horse-power.—It will be seen that in the 'Summary Estimates,' pages 128, 129, the comparison is made per 'Water horse-power' and per 1,000 gallons delivered on height of land. Water horse-power is taken as being the power actually

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[1] An investigation of the Coals of Canada, vols. 1 and 2, 1912.

applied on the column of water to raise the required amount at the required rate. This is thought to be the fairest basis of comparison.

The cost per 'brake' or effective horse-power, though given in the separate estimates, is necessarily less accurate, as:—

(1) It depends on the efficiency of the pumps and varies with both the type and make of pump.

(2) It depends also on the maker's rating of the plant and on the margin he sees fit to allow, which, in turn, depends largely on the inherent overload capacity of the type of plant.

(3) Units cannot always be supplied of the exact size required without unreasonable increase of cost over that for the nearest standard size.

There is, therefore, usually a difference, and sometimes a considerable difference, between the B.H.P. required and the B.H.P. installed, and a comparison made on that basis would be apt to be misleading in this case.

The final and most useful comparison is that headed 'Cost per 1,000 gallons pumped to height of land,' height of land meaning the spot on which the intake to the gravity pipe line is situated.

Average cost.—In studying the summary on pages 128 and 129 and noting the large differences between the cost by the initial and complete installations, it naturally occurs to one to average these figures for each alternative in order to compare one alternative with another and get a general idea of the average result. The figures are therefore written in for this purpose, but they should not be taken as representing a definite result at any particular stage of development or output.

The averages given are simply the arithmetical averages of the column, except in the case of the cost per 1,000 gallons which is put at the rate corresponding to the 'average' total annual cost. The method of obtaining the cost per 1,000 gallons is shown in the first estimate on page 130.

Three points should here be carefully considered:—

(1) As to the initial installation, that the costs are in all cases high, due to the large expenditure for small output, the necessary provision of 100 per cent reserve, the large proportion of management and general expenses, the large proportion for engineering and contingencies, etc.

(2) As to the complete installation, that the costs are in some cases, as for water-power and producer gas, very largely reduced (per horse-power year) from those of the initial installation, but this reduction represents a growth of demand for water from 20,000,000 to 100,000,000 gallons per day, or 400 per cent. Even with the rapidly-growing population of the West it must be many years before this is achieved, possibly twenty-five years or more.

The cost of production by the initial installation must therefore be given equally careful consideration with that by the complete installation.

(3) *Cost of the complete installation.*—While the cost of the initial plant can be quite closely estimated, that of the complete installation cannot well be figured equally closely.

The complete installation will be built up by a series of extensions to the plant over a period of, say, twenty-five years or more. During this period conditions, price of material and fuel, 'state of the art,' etc., etc., may change very considerably, so that it may be inadvisable to continue with the same type of plant.

Furthermore, during this long period, some of the original plant will be worn out or antiquated and have been replaced, and some of the original loans may have been completely paid off, so that the annual capital charges, which in most cases form a large proportion of the total annual cost, (see page 130) may be considerably different from those assumed.

For the purpose of comparison, however, a definite basis had to be assumed, the same for all cases; therefore the estimates are for an initial installation and for a complete installation, and show also the result of averaging these two, in order to give some idea of the general result that would be obtained over a series of years.

Costs.—The price taken for plant, the amount allowed for engineering, contingencies and interest during construction, and the rates allowed for annual capital charges, all, of course, affect the cost of production.

No doubt similar plant could be obtained for lower figures and the amounts allowed for engineering, interest, depreciation, etc., could be cut down below those shown in the estimates.

The objects, however, have been to allow for the highest class plant and buildings, and to give safe figures both as to capital and operating expenditures, that would not be likely to be exceeded in practice.

Summaries of Estimates—A complete summary is given on pages 128 and 129, and other summaries in different form are given. These are followed by the detailed estimates on page 130. These are followed by the detailed estimates, and a 'Review of Alternatives' is given on page 169.

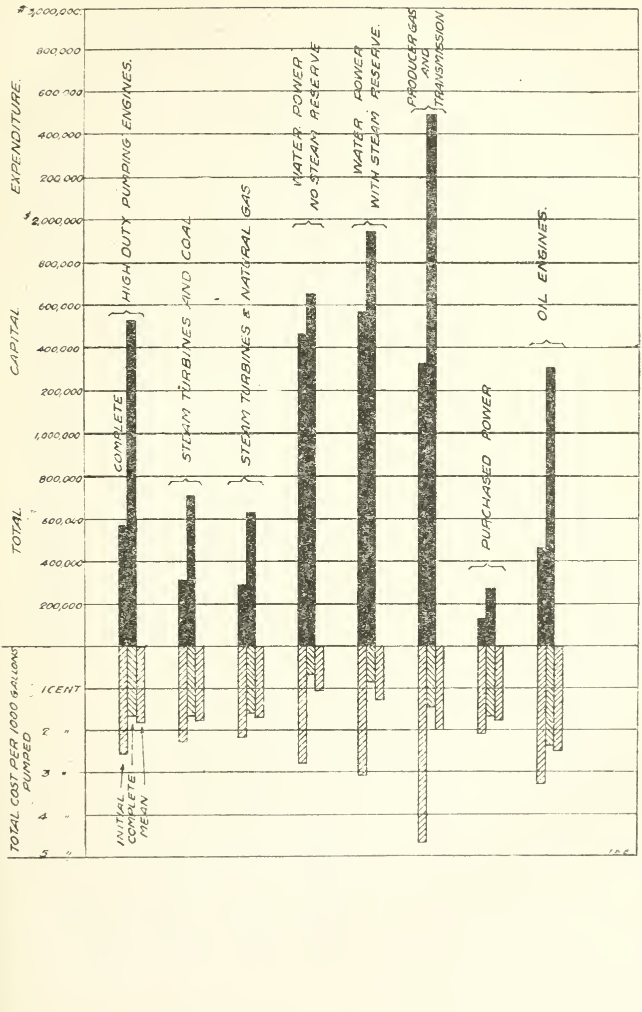

FIG. 3. Diagrammatic representation of summary of estimates.

SUMMARY OF ESTIMATES—POWER PLANT ONLY.

Initial Installation 20,000,000 Gallons Per Day Capacity, 15,000,000 Gallons Output.
Complete Installation 100,000,000 Gallons Per Day Capacity, 75,000,000 Gallons Output.

See remarks on Page Re Water Horse-Power. See also Diagrammatic Representation on the proceding Page.

Type of Plant.	Capital Cost.	Total Annual Cost.	Per cent difference in total cost for each 10 per cent difference in cost of fuel.	Cost Per. Water H. P. installed or required.	Cost Per. W. H. P. Hour in Cents.	Cost Per. W. H. P. Year.	Cost Per. 1,000 Gals. pumped to height of land.	Remarks.
	$	$	%	$		$	Cts.	
High Duty Pumping Engines:—								
Initial Installation	571,400	138,600	3·28	208 00	1 53	100 00	2·54	There might be some trouble with any form of piston pump, owing to the silt in the water, unless first removed.
Complete Installation	1,522,800	457,100	4·73	169 00	1·01	66 50	1 67	
Average	....	297,850	4·00	188 50	1·27	83 25	1·81*	
Steam Turbines and Centrifugal Pumps. Coal:—								
Initial	257,000	124,000	5·20	93 50	1·37	90 00	2·26	Steam plant at the river, coal delivered by rail.
Complete	656,000	453,100	6·76	73 50	1·00	66 00	1·66	
Average	....	288,550	5·98	83 50	1·19	78 00	1·76*	
Steam Turbines and Centrifugal, (with natural gas):—								
Initial	249,700	117,030	5·00	90 70	1·29	85 20	2·14	See remarks under head of 'Natural Gas' re cost of branch pipe line.
Complete	636,290	436,030	6·67	71 25	0·97	63 50	1·60	
Average	....	276,530	5·84	81 00	1·13	74 35	1·68*	
Water Power, (no steam reserve):—								
Initial	1,477,900	151,750	......	536 00	1·68	110 00	2·78	Includes whole cost of dam and buildings against initial installation. This is a very costly development for a comparatively small output.
Complete	1,651,700	189,910	......	185 00	0·42	27 60	0·69	
Average	....	170,830	......	360 00	1·05	68 80	1·04*	

Water Power, (with steam reserve):—								
Initial	1,569,000	166,700	....	570 00	1·85	121 00	3·05	See discussion on advisability of fuel plant reserve .... Steam reserve allowed is small.
Complete	1,945,000	236,500	....	218 00	0·52	35 00	0·86	
Average	....	201,600	......	394 00	1·19	78 00	1·23*	
Producer Gas, (with electric transmission):—								
Initial	1,335,100	256,900	0·93	485 00	2·84	187 00	4·69	Includes separate power and pumping stations, two staffs, double circuit steel tower line lightly loaded, and all transmission and transformation losses.
Complete	2,495,200	391,500	3·36	278 00	0·87	57 00	1·42	
Average	....	324,200	2·15	382 00	1·86	122 00	1·97*	
Purchased Power:—								
Initial	137,340	114,300	6·78	50 00	1·26	83 00	2·09	Based on tentative offer of power delivered and transformed at $38.80 per E. H. P. year. Electric motors and centrifugal pumps in pumping station, supplied and operated by the proposed Water Commission.
Complete	276,650	451,000	8·57	31 00	1·00	66 00	1·65	
Average	.... .	282,650	7·68	40 50	1·13	74 50	1·72*	
Oil Engines (Diesel):—								
Initial	464,140	177,600	5·18	168 00	1·96	129 00	3·24	See Fig. 5. The high cost is mainly due to the excessive cost of fuel oil in Saskatchewan.
Complete	1,369,980	643,200	6·55	146 00	1·42	93 50	2·35	
Average	....	410,400	5·77	157 00	1·69	111 00	2·50*	

OTTAWA, Ont., May 30, 1913.

* See note re 'average' cost on page 125.

See also comparison of principal alternatives on pages 130, 156 on Figs 4 and 5.

COMPARISON of Capital Expenditure and Cost per 1,000 gallons pumped, taking the coal operated turbine plant as unity, for the reason that it shows average capital and operating costs.

Type of Plant.	Capital Cost for Power Plant Only.		Cost per 1,000 Gallons Pumped.	
	Initial.	Complets.	Initial.	Complete.
High duty pumping engines	222	232	113	100
Steam turbines, coal operated	100%	100%	100%	100%
Steam turbines and natural gas	97	97	94·5	96·5
Water power, no steam reserve	575	252	123	41·5
Water power with steam reserve	610	296	135	52
Producer gas, electric transmission	520	380	208	85·5
Purchased power	53·5	42	92·5	100
Oil engines	180	200	143	141

COMPARISON of Annual Charges and Fuel Cost, expressed as a percentage of the total annual cost. (For details see respective estimates on pages noted.)

Type of Plant.	Page.	Capital Charges.		Cost of Fuel or Power.	
		Initial.	Complete.	Initial.	Complete.
High duty pumping engines	130 to 132	43·2%	35·4%	32·8%	47·3%
Steam turbines, coal operated	132, 133	21·7	15·4	52 0	67·6
Steam turbines and natural gas	136, 137	22·3	15·7	50·0	66·7
Water power, no steam reserve	138 to 140	82 9	76 8		
Water power with steam reserve	142 and 144	81·4	75·8		
Producer gas, electric transmission	155, 156	65·0	79·0	9·25	3·4
Purchased power	159, 160	12·6	6·5	67·7	85·7
Oil engines	165 to 168	27·4	21·7	51·8	63·5

HIGH DUTY PUMPING ENGINES. VERTICAL TRIPLE EXPANSION.—COAL OPERATED.

Initial Installation.

Duty, 170,000,000 foot pounds per 1,000 pounds of dry steam. Two units of 20,000,000 gallons capacity each, 1,375 water horse-power, 100 per cent reserve. 75 per cent load factor.

Capital cost—

Two pumping units, with foundations, piping condensers, etc.	$344,000
Two 550 H.P. boilers, with superheaters, stogers, etc.	29,700
Buildings, including crane, conveyor, etc	49,500
Cribs, conduits, wells, suction piping, etc.	50,000
	$473,200
Engineering and contingencies, 15 per cent	70,980
	$544,180
Interest during construction, 5 per cent	27,209
	$571,389

Per W.H.P., $\frac{\$571,400}{2,750} = \$208.$

Annual cost—

	$	Per cent.
Capital charges, 11 per cent on \$473,200, 8 per cent on \$98,189	59,850	43·20
Fuel, Crowsnest coal at \$5.65	45,500	32·80
Labour, three shifts	11,700	8·45
Oil, waste and supplies	3,170	2·30
Repairs and maintenance	6,350	4·60
Management, office and general	12,000	8·65
	\$138,570	100·00

W.H.P. hours = 1,375 x 8,760 x$^{75}/_{100}$ = 9,050,000.

Per W.H.P. hour = $\frac{\$138,750}{9,050,000} = 1·53$ cents.

Per W.H.P. year = $\frac{\$138,570}{1,375} = \$100.$

Cost per 1,000 gallons delivered on height of land: 75 per cent of 20,000,000 gallons = 15,000,000 gallons per day.

Annual cost, \$138,570 = \$380 per day.

$\frac{\$380}{15,000} = 2·54$ cents per 1,000 gallons.

See estimate for complete plant.

Complete Installation.

Five units, total capacity, 130,000,000, of which 30 per cent is reserve.
Working capacity, 100,000,000 gallons = 6,875 W.H.P.
Total installed, 130,000,000 gallons = 8,950 W.H.P.

Capital cost—

Two pumping units, 20,000,000 gallons	\$344,000
Three pumping units, 30,000,000 gallons	680,000
Six 550 H.P. boilers and accessories	89,100
Buildings, crane, conveyors, etc.	161,000
Cribs, conduits, well, piping	75,000
	\$1,349,000
Engineering and contingencies, 7½ per cent	101,200
	\$1,450,300
Interest during construction, 5 per cent	72,520
	\$1,522,820

Per W.H.P. installed, $\frac{\$1,522,800}{8,950} = \$169.$

Annual cost—

	$	Per cent.
Capital charges, 11 per cent on \$1,349,000, 8 per cent on \$173,720	161,900	35·42
Fuel	216,130	47·30
Labour	32,250	7·05

Oil, waste and supplies	8,940	1·95
Repairs and maintenance	17,880	3·91
Management, office and general	20,000	4·37
	$457,100	100·00

W.H.P. hours, 45,250,000.

Per W.H.P. hour, 1·01 cents.

Per W.H.P. year (6,875 H.P.), $66.59.

Per 1,000 gallons delivered on height of land, 1·67 cents.

Price of coal.—Each 10 per cent difference in cost of coal will make 4·73 per cent difference in total cost.

STEAM TURBINE DRIVEN CENTRIFUGAL PUMPS.—COAL.—120,000,000 duty.

Initial Installation.

Capital cost—

Two pumping units, 20,000,000 gallons each, complete	$82,500
Two 750 horse-power boilers and accessories	39,000
Buildings, including crane, conveyor, etc.	41,300
Cribs, conduits, wells, etc.	50,000
	212,800
Engineering and contingencies, 15 per cent	31,920
	$244,720
Interest during construction, 5 per cent	12,236
	$256,956

Per W.H.P. installed, $93.50.

	$	Per cent.
Capital charges, 11 per cent on $212,800, 8 per cent on $44,156	26,940	21·70
Fuel, Crowsnest at $5.65	64,500	52·00
Labour	11,700	9·45
Oil, waste and supplies	2,500	2·02
Repairs and maintenance	6,350	5·13
Management, office and general	12,000	9·70
	$123,990	100·00

Per W.H.P., 1·37 cents.

Per W.H.P. year, $90.

Per 1,000 gallons delivered on height of land, 2·26 cents.

Coal.—Each 10 per cent difference in cost of coal will make 5·2 per cent difference in total cost.

See estimate for complete plant.

Complete Installation.

Capital cost.—

Two pumping units, 20,000,000 gallons	$ 82,500
Three pumping units, 30,000,000 gallons	173,040
Six 750-H.P. boilers and accessories	117,000

Buildings, including crane, conveyors, bunkers, etc.	134,250
Cribs, conduits, wells, etc.	75,000
	$581,790
Engineering and contingencies, 7½ per cent.	43,600
	$625,390
Interest during construction, 5 per cent.	31,270
	$656,660

Per W.H.P. installed, $73.50.

Annual cost—

	$	Per cent.
Capital charges, 11 per cent on $581,800, 8 per cent on $74,870	69,980	15·41
Fuel	306,000	67·60
Labour	32,250	7·12
Oil, waste and supplies	7,000	1·53
Repairs and maintenance	17,880	3·93
Management, office and general	20,000	4·41
	$453,110	100·00

Per W.H.P. hour, 1·00 cents.
Per W.H.P. year, $66.
Per 1,000 gallons delivered on height of land, 1·66 cents.

Coal.—Each 10 per cent difference in cost of coal will make 6·76 per cent difference in total cost.

STEAM PLANT.

It will be sen by reference to the summary on pages 128 and 129, and the detailed estimates, that steam turbine plant, under the conditions to be met, offers low capital cost and reasonable cost per 1,000 gallons pumped.

Comparisons with the other most favourable alternatives are discussed and tabulated under the head of 'Water-power,' pages 137-144, 'Purchase of Power,' page 159 and 'Oil Engines,' page 161 and diagram, on page 167.

Some of the special advantages of steam power may be here pointed out and these should be considered after studying the questions of first cost and operating cost as discussed under the above references.

Steam plant offers the advantages of:—

1. Low first cost for both initial and complete installations.
2. Low total annual cost in the early stages.
3. No transmission line losses and risks.
4. Plant of a type of thoroughly proved reliability.
5. No risks from ice and floods.
6. Alternative sources of fuel. Steam boilers could be adapted for coal, oil, natural or producer gas firing, as future conditions arising from development of the country may make desirable.
7. Large overload capacity.

Also, in this case, the water is 'excellent for steam boilers' and in accordance with standard waterworks practice, the circulating water for cendensing purposes could consist of the water pumped for city use, so that the full advantage of ample condensing water is obtained at small expenditure.

On the other hand, as shown on page 144 and discussed under the head of 'Review of Alternatives,' on page 169, steam power would not give low costs for an output much over 25,000,000 gallons per day.

NATURAL GAS.

In view of the proposals made by Mr. William Georgeson, of Calgary, who is understood to also represent other local capitalists, to pipe natural gas from Alberta to Winnipeg, and to supply other cities on the route, consideration has been given to natural gas as a possible source of power for pumping.

The proposal made to Moosejaw, Regina, Winnipeg and other cities was to supply gas 'in bulk' to the municipalities, not including distribution, at 25 cents per 1,000 cubic feet.

The subject of a supply for pumping was discussed with Mr. Georgeson, who expressed himself as prepared to undertake it at the above price.

The distance from the Alberta gas fields to Winnipeg is about 650 miles and to Moosejaw about 300 miles. It has been reported that the city of Winnipeg is seriously considering an offer from the proposed company to supply and distribute the gas at 40 cents per 1,000. It has also been reported that the city of Regina is favourably disposed to closing a contract for a supply in bulk at 25 cents. The cost of the complete undertaking to supply as far as Winnipeg is estimated at $20,000,000.

It has also been stated that if Winnipeg should not enter into a contract the supply would in any case be taken as far as Regina.

The following are some examples of long distance transmission of natural gas and the prices charged:—

City.	Length of transmission.	Price per 1,000 cubic feet for power.
Calgary, Alta.......	170 miles.....	20 cents, over 50,000 cubic feet per day 15 cents [1].
Kansas city.........	250 "	Summer rate; first 200,000 cubic feet, 29 cents per 1,000; each 1,000 beyond, 12 cents. Winter; 29 cents for any quantity.
Topeka, Kansas.....	200 "	10 to 25 cents.
Oklahoma city.....	110 "	$12\frac{1}{2}$ to 30 cents.
Cincinnati..........	120 "	11 to 30 cents.
Pittsburg	142 "	13 to $27\frac{1}{2}$ cents.
Toledo, Ohio	300 "	35 cents net. Special summer rates to large users.
Kansas city and Oklahoma city	....	Special rate to glass manufacturers, 3 to 7 cents.

From which it will be seen that the length of transmission to Moosejaw (300 miles) and Regina (345 miles) is not prohibitive.

The cost of a branch line from the main pipe to the pumping station would be a considerable item. It will be seen from 'Access to pumping station,' that the shortest distance in an air line from the Canadian Pacific Railway line is 23 miles. If we add 10 per cent for diversions, this is over 25 miles.

In Mr. Eugene Coste's report to the Canadian Western Natural Gas, Light, Heat and Power Company, of Calgary, he estimates the cost of 175 miles of 16-inch pipe laid complete between Bow Island and Calgary at $12,000 per mile. Mr. R. L. Shimmin, engineer to Mr. Georgeson's company, estimated the cost of a 6-inch to 4-inch pipe line from Moosejaw to Elbow at $7,500 per mile.

[1] Includes distribution under a franchise. This is stated to provide that of the net profits 2 per cent shall first be paid to the city, then 10 per cent to the stockholders and then 3 per cent of any further profits to the city.

The exact size of pipe would not greatly affect the cost, which would largely be made up of transportation, trenching, right of way, etc.

If the cost is taken at $8,000 per mile the cost for twenty-five miles would be $200,000, on which interest, 5 per cent; sinking fund, 2 per cent; repairs and maintenance, 2 per cent; taxes, 1 per cent; total, 10 per cent, would give an annual charge of $20,000.

Reliability.—There is always the possibility of failure of the gas wells, involving interruption or diminution of the supply for an indefinite period. If the supply could not be renewed or increased by new wells feeding into the same pipe lines, as has been done in other cases, the capital invested in the pipe lines would be lost.

Furthermore, the continuity of supply is dependent on a single pipe line which may be put out of service by faulty workmanship or material, sinking of ground, spring freshets or floods, etc.

There is also the possibility of a dry supply becoming wet, not only diminishing its value and serviceability, but bringing in the risk of interruption from frost.

For the above reasons it does not appear desirable to depend upon natural gas as the only source of power for the water supply to a number of cities. There should be an alternative source that could be immediately brought into service in the event of a failure in the gas supply.

A steam plant installation gives this alternative. The boilers can be designed to be hand fired by coal if necessary and a supply of coal kept on hand at all times.

A gas engine installation to be operated by natural gas does not give this security and, furthermore, if the gas supply failed the capital invested in the plant would be lost in addition to that in the pipe line.

The installation of gas engines at the pumping station has therefore not been considered, but we may proceed to consider the effect on the cost of power of using natural gas instead of coal under steam boilers adapted to be used with either fuel.

Comparison.—Referring to the summary, on pages 128 and 129, it will be seen, comparing the average results from the initial and complete installations, that as between the high duty and steam turbine centrifugal plants, the latter appears to offer the lowest capital and annual costs; it also involves the largest fuel consumption and is most favourable to the comparison with gas.

We will therefore make the comparison between natural gas and coal for operating steam turbine driven centrifugal pumps.

Possible savings.—These would consist of reduction in cost of fuel and reduction in cost of boilers by dispensing with mechanical stokers. The other estimates are intended to include mechanical handling of the coal and the minimum of labour, so that there could not well be much saving on this item, especially as it would be advisable in so isolated a plant and one for this purpose, to have never less than two stokers on duty.

The allowance included in other estimates for coal storage, bunkers, etc., could not be dispensed with or much reduced as it would be required for reserve though not for daily use.

Taking natural gas at 25 cents per 1,000 cubic feet, 40 cubic feet per boiler horse-power hour actually used to develop power, and a saving of $4 per boiler horse-power installed for mechanical stokers, the average saving would be about $12,000 per annum, or about 4·2 per cent on the total annual costs. (See summary, pages 128 and 129.)

It therefore appears that the saving due to natural gas at 25 cents per 1,000 cubic feet would probably be but small. Furthermore, it must be noted that such saving would only be made if the gas was delivered at the pumping station at that figure.

If the cost of the pipe line is $200,000 as above, on which the annual charges at 10 per cent would be $20,000, it appears that the purchasers could not afford to bear the cost of this pipe line.

On the above basis of cost of pipe and quantity of gas, the cost of the pipe would add an average of 2·06 cents per 1,000 cubic feet to the cost of the gas.

STEAM TURBINE DRIVEN CENTRIFUGAL PUMPS—NATURAL GAS UNDER BOILERS.

Initial installation.

Capital cost—

Two pumping units as before	$ 82,500
Two 750 horse-power boilers and accessories	33,000
Buildings, crane, conveyors, etc.	41,300
Wells, conduits, etc.	50,000
	$206,800
Engineering and contingencies, 15 per cent	31,020
	$237,820
Interest during construction, 5 per cent	11,890
	$249,710

Per W.H.P. installed, $90.70.

Annual cost—

	$	Per cent.
Capital charges, 11 per cent on $206,800, 8 per cent on $42,910	26,180	22·30
Fuel, 25 cents per 1,000 cubic feet	58,300	49·96
Labour	11,700	10·00
Oil, waste and supplies	2,500	2·13
Repairs and maintenance	6,350	5·40
Management, office and general	12,000	10·21
	$117,030	100·00

Per W.H.P. hour, 1·29 cents.
Per W.H.P. year, $85.20.
Per 1,000 gallons delivered on height of land, 2·14 cents.

Fuel.—Each 10 per cent difference in price of fuel will make 5 per cent difference in total costs.

See estimate for complete plant.

Complete Installation.

Capital cost—

Two pumping units as before	$ 82,500
Three pumping units as before	173,040
Six 750 horse-power boilers and accessories	99,000
Buildings, crane, conveyors, etc.	134,250
Well, conduits, etc.	75,000
	$563,790
Engineering and contingencies, 7½ per cent	42,200
	$605,990
Interest during construction, 5 per cent	30,299
	$636,289

Per W.H.P. installed, $71.25.

Annual cost—

	$	Per cent.
Capital charges, 11 per cent on $563,790, 8 per cent on $72,500	67,900	15·65
Fuel	291,000	66·65
Labour	32,250	7·40
Oil, waste and supplies	7,000	1·60
Repairs and maintenance	17,880	4·10
Management, office and general	20,000	4·60
	$436,030	100·00

Per W.H.P. hour, 0·965 cents.
Per W.H.P., year, $63.50.
Per 1,000 gallons delivered on height of land, 1·60 cents.

Fuel.—Each 10 per cent difference in cost of fuel will make 6·7 per cent difference in total cost.

WATER-POWER.

In making extensions to a water-power station from time to time, much expense and delay would be incurred in carrying out the necessary temporary works to exclude water.

It is therefore assumed that it would in this case be advisable to complete the buildings, wheel pits, and tail-races for the final capacity of the plant, while putting in the initial installation.

Especially is this the case as the difference in cost would be only about $60,000, which is a comparatively small item in the total expenditure.

This additional expenditure against the initial installation does not occur in the case of any of the other alternatives. On the other hand all the alternatives are charged with $50,000 to $75,000 as the cost of cribs, conduits and wells for supplying water to the pumps, which would not be necessary in the case of the water-power station.

The following estimates of the cost of water-power do not include any steam reserve, and attention is called to the notes on this subject on page 140.

Initial Installation.

Two units of 20,000,000 gallons capacity each per day, one being reserve. Thirty-seven feet head for power.

Capital cost—

Approximate cost of dam, sluice gates, etc., as per Mr. Peter's estimate		$1,000,000
Two horizontal water turbines direct connected to centrifugal pumps, with governors, flexible couplings, etc.	$ 67,200	
Piping and valves inside station, rough labour for erection of sets, accessories, etc.	8,000	
Excavations, buildings and foundations, including wheel pits and tail-races, of capacity for the final installation	93,690	
Racks, stoplogs and gear	15,000	
Crane	6,000	
		189,890
		1,189,890
Engineering and contingencies, 15 per cent		178,480
		1,368,370
Interest during construction, 5 per cent, two years on dam, one year on power plant		109,490
		$1,477,860

Per B.H.P. of turbines installed, $\frac{\$1,478,000}{4,200} = \$350.$

Per W.H.P. required, $\frac{\$1,478,000}{2,750} = \$536.$

Annual cost—

	$	Per cent.
Capital charges, dam, interest, 5 per cent; sinking fund, 50 years, 3 per cent compound = 0·9 per cent; repairs and maintenance, 1 per cent; taxes, 1 per cent; total, 8 per cent	80,000	52·80
Power plant and buildings, interest, 5 per cent; sinking 3 per cent; depreciation, 2 per cent; insurance and taxes, 2 per cent; total, 12 per cent; 12 per cent on $189,890, 8 per cent on $287,970	45,800	30·10
Labour	9,150	6·03
Oil, waste and supplies	1,000	·66
Repairs and maintenance on power plant and buildings, 2 per cent	3,800	2·50
Management, office and general	12,000	7·91
	$151,750	100·00

Efficiency of pumps, 75 per cent, 1,375 W.H.P. x $\frac{100}{75}$ = 1,835 B.H.P.

Average load, 75 per cent—

1,835 x $\frac{75}{100}$ x 8,760 = 12,050,000 B.H.P. hours.

Per B.H.P. hour, $\frac{\$151,750}{12,050,000}$ =1·26 cents.

Per W.H.P. hour, 1.26 x $\frac{100}{75}$ = 1·68 cents.

Per W.H.P. year, $\frac{\$151,750}{1,375}$ =\$110.

Per 1,000 gallons delivered on height of land—

75 per cent of 20,000,000 gallons = 15,000,000 gallons per day.

Annual cost, \$151,750 = \$416 per day.

$\frac{\$416}{15,000}$ =2·78 cents.

Complete Installation.

Two units of 20,000,000 gallons capacity each per 24 hours.

Three units of 30,000,000 gallons capacity each per 24 hours. One 30,000,000 gallon unit being reserve.

Capital cost—

Dam, as before		\$1,000,000
Buildings	\$93,690	
Racks, etc	15,000	
Crane	6,000	
Two 2,100 horse-power turbines and pumps, as before	67,200	
Three 3,150 horse-power turbines and pumps	136,500	
Piping and valves inside station, rough labour for erection of sets, accessories, etc., as before	8,000	
Ditto for next three sets	18,000	
		344,390
		\$1,344,390
Engineering and contingencies at previous figure, plus 7½ per cent on additional \$154,500		190,067
		\$1,534,457
Interest during construction, 5 per cent, 2 years on dam, 1 year on power plant		117,219
		\$1,651,676

Per B.H.P. of turbine installed, $\frac{\$1,652,000}{13,650}$ = \$121.

Per W.H.P. required, $\frac{\$1,652,000}{8,950}$ = \$185.

	\$	Per cent.
Annual cost—		
Capital charges, dam as before	80,000	42·10
Power plant and buildings, 12 per cent on \$344,390, 8 per cent on \$307,286	65,900	34·71

		Per cent.
Labour	15,120	7·98
Oil, waste and supplies	2,000	1·05
Repairs and maintenance on power plant and buildings, 2 per cent	6,890	3·63
Management, office and general	20,000	10·53
	$189,910	100·00

Efficiency of pumps, 75 per cent, 6,875 W.H.P. x $\frac{100}{75}$ =9,166 B.H.P.

9,166 x $\frac{75}{100}$ x 8,760 (average load 75 per cent) = 60,200,000 B.H.P.

Per B.H.P. hour, $\frac{\$189{,}910}{60{,}200{,}000}$ = 0·315 cents.

Per W.H.P. hour, 0·315 x $\frac{100}{75}$ = 0·42 cents.

Per W.H.P. year, $\frac{\$189{,}910}{6{,}875}$ = $27.60.

Per 1,000 gallons delivered on height of land—

$\frac{\$189{,}910}{365 \times 75{,}000}$ = 0·693 cents.

STEAM RESERVE TO WATER-POWER PLANT.

It is now very generally recognized and the principle is being rapidly applied, that steam reserve is in most cases a necessary adjunct to hydro-electric plant, if continuity of service is to be reasonably assured.

In the case under consideration, the supply of water for all purposes to a number of towns, continuity of operation is of vital importance and every reasonable precaution must be taken against interruption of service from the water plant due to ice, floods, etc.

In the report of the Commissioner of Corporations on Water Power Development in the United States, March 4, 1912, (1) it is stated that: "Hydraulic concerns usually provide themselves with steam auxiliaries . . . There sometimes arise emergencies when the steam auxiliary is an absolute necessity.'

Mr. Charles T. Main, the well-known consulting engineer of Boston, Mass. stated before the Boston Society of Civil Engineers (2) that: 'Generally a water power tends to have a rather low factor of reliability, due to the fact that there is usually only one dam, one power house and often a long transmission line, besides risks from floods and droughts.'

Mr. E. A. Graham. assistant engineer to the Winnipeg Electric Railway Company states (3) that: 'It is becoming recognized more and more every day that hydro-electric plants. no matter how well built and operated, serve the public best when they are insured by a well-equipped auxiliary plant . . . In the case of a single hydro-electric plant the auxiliary plant should be of at least half its capacity.'

A recent number of the *Electrical News* (Jan. 1, 1913) says in an editorial that:

'The present day tendency in the larger hydro-electric plants in Canada is decidedly in favour of some form of auxiliary equipment. The present

[1] Government Printing Office, Washington. 1912.
[2] *Electrical World*, N.Y., December 23, 1909.
[3] *The Electrical News*, Toronto, January 1, 1913.

issue contains a description of the new steam station of the Winnipeg Electric Railway Company . . . recent issues have described similar steam stations in Victoria and Vancouver of the British Columbia Electric Traction Company.

'At the present time the Toronto Railway Company and the Toronto Electric Light Company (who obtain hydro-electric energy from the Electric Development Company's modern plant at Niagara Falls) are installing auxiliaries in the form of both steam turbo-generators and very large storage batteries. The Electric Power Company is just completing the installation of Diesel oil standby in Oshawa in addition to several steam plants already available at different points along their distributing system.

'The Ottawa Light Heat and Power Company and the Ottawa Street Railway Company are also at present increasing their auxiliary equipment, and many other companies are following the same policy. It is noticeable too that these companies are all or nearly all possessed of what may be almost considered as unlimited water-powers operating under very favourable conditions.'

The following table gives a few examples of the scale on which Canadian hydro-electric companies are providing steam or other reserve:—

STEAM RESERVE OF CANADIAN HYDRO-ELECTRIC PLANTS.

APPROXIMATE FIGURES.

City or Company.	Hydraulic Plant.	Steam Reserve.
Dominion Power and Transmission Company, Hamilton	21,800 k.w.	5,200 h.p.
Montreal Light, Heat and Power Company	34,000 k.w.	7,500 h.p.
Ottawa Electric Company (1500 H. P. hydraulic purchased)	6,520 k.w.	1,500 h.p.
British Columbia Electric Traction Company	35,000 k.w.	15,300 h.p.
Toronto Electric Light Company	Niagara.	20,000 h.p.
City of Calgary, Alberta	Calgary Power Co.	9,000 h.p.
Winnipeg Electric Railway Company	17,000 k.w.	17,000 h.p.
Canadian Light and Power (St. Lawrence River)	15,000 k.p.	4,000 h.p.

The practice in the United States appears to be similar; for instance, the Southern Power Company, one of the largest hydro-electric concerns in the country, has two 8,000 k.w. auxiliary steam turbine generating stations and the Seattle municipality has allowed for a 5,000 k.w. steam reserve plant in connection with its new hydro-electric development. ([1])

If it is considered that in the present case a steam or other fuel reserve is advisable, then it must be of sufficient size to form an adequate reserve; it should be remembered, however, that the proposed gravity pipe line, without counting branch lines, would contain, when full, about 300,000,000 gallons (170 miles of pipe from 10 feet 6 inches to 6 feet 5 inches in diameter) forming in itself considerable storage and reserve.

If, therefore, the reserve fuel plant was of about one-third the capacity of the initial plant and about one-fourth the capacity of the complete plant, it would probably give sufficient security, as the gravity pipe could be pumped up full during hours of light demand.

[1] *Journal of Electricity Power and Gas*, San Francisco, August 8, 1912.

A steam plant merely held as reserve and used only occasionally, would be subject to less repairs and maintenance and less consumption of supplies, though probably not to less depreciation.

Requirements for economy, such as superheaters and economizers, would not be necessary. The operators of the water-power plant could be steam engineers capable of running the steam plant when required, but some additional men would need to be available for attending to the boilers and also for attention to the plant to keep it ready for service.

Under the above conditions the cost of such auxiliary plant would be about as follows:—

COST OF STEAM RESERVE.

Initial Plant.

Capital cost.—

600 horse-power steam turbine and centrifugal pump unit complete with buildings, boilers and accessories	$ 54,000
Cribs, conduits and wells	25,000
	79,000
Engineering and contingencies, 10 per cent	7,900
	86,900
Interest during construction, 5 per cent	4,350
	$ 91,250

Annual cost.—

Capital charges, 11 per cent on $79,000, 8 per cent on $12,250	$ 9,670
Fuel, allow	2,000
Labour, two extra men at $70 per month	1,680
Oil, waste, supplies	250
Repairs and maintenance, 1 per cent	790
Proportion of management, office and general	500
	$14,890

Complete Plant.

Capital cost.—

2,400 horse-power of steam turbine and centrifugal pump plant, complete with boilers, buildings and accessories	$204,000
Cribs, conduits and wells	50,000
	254,000
Engineering and contingencies, 10 per cent	25,400
	279,400
Interest during construction, 5 per cent	14,000
	$293,400

COMPARISON OF TOTAL ANNUAL COST.

OVER AN ASSUMED PERIOD OF TIME

WATER POWER WITH SMALL STEAM RESERVE

VERSUS

STEAM TURBINES WITH COAL.

FOR THE PARTICULAR CONDITIONS CONSIDERED

NOTE: THE RESPECTIVE CAPITAL COSTS ARE ESTIMATED AT

	INITIAL	COMPLETE
WATER POWER.	$1,569,000	$1,945,000
STEAM TURBINES.	257,000	656,000
DIFFERENCE.	$1,312,000.	$1,289,000.

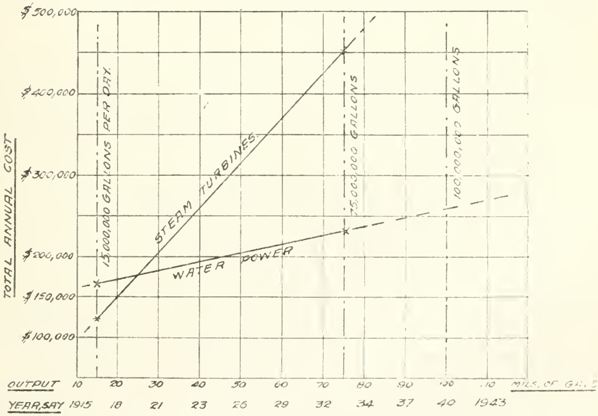

Fig. 4.

Annual cost.—

Capital charges, 11 per cent on $279,000, 8 per cent on $39,400..	33,760
Fuel, allow..	6,000
Labour, three extra men at $70 per month..	2,520
Oil, waste and supplies..	750
Repairs and maintenance, 1 per cent..	2,540
Proportion of management, office and general..	1,000
	$46,570

Adding the above amounts to the cost of water-power plant without steam reserve, the results shown in the summary on pages 128 and 129 are obtained.

It will be observed that the water-power plant will, mainly owing to the cost of the dam, involve capital expenditure of about $1,000,000 in excess of that necessary for a steam turbine plant.

The water-power plant, either with or without steam reserve, involves greater cost per 1,000 gallons pumped than the steam turbine plant up to an output of about 25,000,000 gallons per day (see fig. 4).

Beyond this point the advantage is in favour of the water-power plant and this advantage increases so rapidly that on an output of 75,000,000 gallons per day the cost per 1,000 gallons pumped is 0·86 cents by the water-power plant (with steam reserve) against 1·66 cents by the steam turbine plant, or about one-half.

This economy, however, is only secured, as pointed out above, by the initial expenditure of an additional $1,000,000 or thereabouts, and this expenditure not only provides no economy in the early stages but would be a burden on account of the extra capital charges to be met.

PRODUCER GAS PLANT.

Some of the principal troubles in the production of producer gas for power purposes from bituminous coal and lignites are due to:—

(1) Tar, or tarry matter in the gas, causing clogging of the pipes, engine valves, etc., and necessitating considerable complication and expense for gas washers and scrubbers.

(2) Excessive amount of manual labour for stoking and cleaning fires, breaking up 'caking' coal, &c., leading to waste of partly burnt fuel.

(3) Formation of clinker, to avoid which quite large quantities of live steam must sometimes be mixed with the air supply, involving not only considerable expense, but also decreasing the calorific value of the gas produced.

(4) Non-uniform quality of the gas.

The lignite deposits of south Saskatchewan furnish a fuel which appears to be particularly suited for the making of producer gas with a minimum of difficulty from the above causes.

The test made by the Department of Mines, Ottawa, (1) on these coals for this purpose show very favourable results and are dealt with in considerable detail in the report issued on the subject.

Taylorton lignites.—Concerning this fuel from the Estevan district, the above quoted report states that while it has low calorific value, is high in ash and contains much intrinsic moisture, the trials showed that it is very suitable for the making of producer gas, and that:—

(1) The gas contained no tar and it was not necessary to use either gas washer or scrubber.

(1) An Investigation of the Coals of Canada, vol. II, 1912.

(2) The fuel was easy to work, there was no caking and very little attention to the fire was required.

(3) Little or no steam was required.

(4) Good efficiency was obtained with gas of high calorific value and uniform quality.

(5) The fuel appeared much more suitable for use in a properly designed gas producer than in an ordinary steam boiler.

Lake of the Rivers District.—Particulars of the fuel produced by the Consumers' Coal Company are given under that head, but for comparison the conclusions of the special report (1) of the Mines Department on this fuel may be repeated here:—

'The fuel burned uniformly without the formation of troublesome clinker.

'The gas generated was tar-free and the heating value satisfactory.

'The engine valves were found to be exceptionally clean after a run of 40 hours.

'The lignite may be pronounced an excellent fuel for the production of power when utilized in a producer gas plant as it arrives from the mines, without further treatment. The tendency to disintegrate does not in any way interfere with its operation.'

The principal data concerning these fuels, as contained in the above quoted reports, may be summarized thus:—

	Western Dominion Collieries, Taylorton.	Consumers Coal Company, Lake of the Rivers.
Class of coal—Lignite	Run of mine.	Run of mine.
Horse Power of plant	40 B.H.P.	.....
Length of test	24 hours.	40 hours.
Fuel, heat units in dry coal	10,690	10,000 B.T.U.
Fuel, heat units as charged	8,300	.....
Fuel, per B.H.P. including auxiliaries	2.58 lbs.	.....
Gas, effective heat units	112.7 B.T.U.	115
Gas, cubic feet per pound coal	42.5	(2)
Producer efficiency	57.8	.....

	Proximate Analysis. Coal as Charged.			
	Fixed carbon.	Volatile matter.	Ash.	Moisture.
Western Dominion Collieries	36.7	32.8	7.2	23.3
Consumers Coal Company	31.32	28.29	7.97	32.42

These conclusions are practically confirmed by the numerous and thorough tests made by the United States Bureau of Mines on North Dakota and other lignites. (3) The Saskatchewan (Souris) and North Dakota deposits are stated to be geologically part of the same coal 'Field.'

On page 118 of the Department of Mines (Ottawa) report before referred to, there is given a comparative table of the heat expenditure for generating producer

(1) Letter of July 12, 1912.

[2] Insufficient quantity of coal sent to determine volume of gas generated, but indications were that it would have been satisfactory.

[3] For details see Bulletin 13 and Technical Paper 9.

gas for power purposes with representative Canadian coals. Concerning this table it is stated that:—

> 'This table . . . would give the proportional cost for fuel assuming that all the coals were sold at the same price per 1000 B.T.U. This order of arrangement is not quite fair to some coals and gives others some slight undue advantage, but affords a general idea of the relative performance of the various groups.'

The table includes twenty-eight coals of all classes taken from coast to coast, and shows that, in terms of heat units per B.H.P. hour, the Taylorton lignite takes second place for producer gas purposes, the first place being held by Edmonton lignite.

This table brings out the point that the higher quality coals are not necessarily the best for gas producer purposes.

In Technical Paper 9 of the United States Bureau of Mines, it is stated that:—

> 'It was found that the low grade lignite of North Dakota developed as much power when converted into producer gas as did the best West Virginia bituminous coals burned under the steam boiler. It is estimated that on an average each coal tested in the producer gas plant developed two and one-half times the power that it would develop in the ordinary steam boiler plant.'

From the above it will be seen that the local lignites are in every way suitable for a producer gas plant and that they are of a nature to minimize the capital and operating costs of such a plant.

Furthermore, it is probable that the lignite deposits in still closer proximity to the proposed pumping station would possess similar characteristics.

PRODUCER GAS PLANT ON THE COAL FIELD—GAS ENGINES.

Initial Installation.

Maximum load = 2,590 B.H.P., average 1,940 B.H.P.

Pressure plant without ammonia recovery.

One spare unit = 100 per cent reserve.

Lignite screenings, about 8,500 B.T.U. as fired. $1 per ton at the mine direct to conveyors and bunkers.

Capital cost—

Two 2,600 B.H.P. gas electric sets	$224,000
Gas producers for 6,000 B.H.P. (half reserve)	90,000
Switchboards, transformers, etc.	31,200
Crane, coal and ash conveyors, small bunkers (mine dump forms storage)	9,000
Buildings and foundations	56,000
	$410,200
Engineering and contingencies, 10 per cent	41,020
	$451,220
Interest during construction, 5 per cent	22,560
	$473,780

Per B.H.P., $91. Per K.W., $133.

	$	Per cent.
Annual cost—		
Capital charges: Interest, 5 per cent; sinking fund, 3 per cent; depreciation, 3 per cent; insurance and taxes, 2 per cent; total, 13 per cent. 13 per cent on $410,200, 8 per cent on $63,580..	58,580	46·50
Fuel, 17,000,000 B.H.P. hours, 2 80 lbs..	23,800	18·87
Labour..	11,700	9·29
Oil, waste and supplies, 0·45 cents per B.H.P..	7,650	6·08
Repairs and maintenance, 3 per cent on $410,000..	12,300	9·76
Management, office and general..	12,000	9 50
	$126,030	100·00

Per B.H.P. hour, $\frac{\$126,000}{17,000,000} = 0{\cdot}74$ cents.

Per B.H.P. year, $\frac{\$126,000}{2,590} = \$48.60$.

Per K.W., year, $\frac{\$48.60 \times 1,000 \times 100}{746 \quad 92} = \$71$.

See also complete installation.

PRODUCER GAS.

Recovery of By-products.

For a plant of the size of the initial installation, with an estimated average output at the rate of 1,940 B.H.P., it is doubtful whether therecovery of by-products would pay. It is understood that the makers of the Mond gas plant, for instance, do not recommend the recovery of by-products in plants of less than 3,000 horse-power, and Mr. Fernald (1) puts this at 3,000 to 4,000 horse-power, though smaller recovery plants are in operation.

The ultimate installation to provide power for pumping 100,000,000 gallons per day would, however, require a capacity of about 13,000 B.H.P., and at 75 per cent load the average output would be at the rate of 9,750 B.H.P.

The recovery of by-products should then, and in fact long before the maximum output is reached, be a commercial and profitable business.

No definite information appears to be available as to the yield of by-produets from Saskatchewan lignites, but in order to form some idea as to what this might amount to in the case under consideration, some recently published particulars (2) of the operations of a large company who have given special attention to the recovery of by-products may be here given. This company is the South Staffordshire Mond Gas (Power and Heating) Company, who manufacture producer gas by the Mond process for distribution through pipes at Dudley Port, England. Their area of supply is 123 square miles and includes six municipalities and over 2,000 factories.

The plant consists of eight producers rated at 20 tons per 24 hours each. The total working capacity was designed to gasify 140 tons of coal per 24 hours, but it is found that the producers can be readily worked at 50 per cent overload and the plant has dealt with 200 tons of coal per day and made, on peak load, 1,000,000 cubic feet of gas per hour.

[1] U. S. Bureau of Mines, Bulletin 13, page 65.

[2] The Generation and Distribution of Producer Gas in South Staffordshire, H. A. Humphrey, Proc. Inst., C.E., 1912.

Public supply was commenced in May, 1905, and until the date of the report (about September, 1912) there is stated not to have been a single stoppage of the gas supply from the station.

Gas.—The average analysis of the gas is:—

	Volume per cent.
CO_2	17·40
CO	10·31
H_2	25·55
CH_4	3·25
N_2	43·49
	100·00

Higher calorific value, 151·33 B.T.U.

Coal.—A large number of fuels have been used successfully during the past seven years.

The analysis of the present bituminous slack is:—

	Per cent.
Ash	10·40
Volatile matter	35·30
Nitrogen	1·16
Moisture	10·50

Calorific value, 11,466 B.T.U.

Price of gas.—In June, 1912, the average price realized was 3·6 cents per 1,000 cubic feet, delivered.

Costs.—The results actually obtained in 1912, when gasifying coal at the rate of 40,000 tons per annum, were:—

	Cents.	
Slack for producers and boilers	1·59	
Cost of manufacturing, including wages, materials, acids, stores, etc., and all repairs and maintenance	1·42	
	3·01	
By sale of by-products	2·20	
Net cost, including general charges	0·81	
General charges, including interest on debentures but not on share capital. (Paid-up capital $1,608,000, including $448,000 of debentures.)	1·79	
Cost per 1,000 cubic feet of gas made		2·60

Note.—This includes distribution in an extensive system of pipes, and carriage of coal by rail.

By-products obtained.—With 3,300 tons of bituminous slack gasified per month the by-products sold were approximately:—

Tar	280 tons per month.
Sulphate of ammonia	120 tons per month.

The tar is used for roofing, paving, briquetting and by tar distilleries. The ammonia is used principally in the manufacture of artificial manure. Both the annual consumption and the market price of sulphate of ammonia have been increasing during the last ten years.

The above figures may now be applied to the final installation of the plant under consideration. They are the results from bituminous slack and the proportion of by-products obtainable from Saskatchewan lignites is not known.

The following points, however, may be taken as a rough guide.

The production of ammonia is largely dependent upon the proportion of nitrogen in the fuel. From the above it will be seen that the coal used at Dudley Port contained 1·6 per cent. The Saskatchewan lignites contain 1 per cent to 1·1 per cent, (1) say 1·05 per cent.

The proportion of tar at Dudley Port is equivalent to 170 pounds per ton of 2,000 pounds of coal. The United States Government tests (2) on Dakota lignites showed a production of 66·91 and 97 pounds per ton from different samples, say an average of 85 pounds; in all cases with water extracted.

It would seem advisable, therefore, to reduce the estimates in the above proportions.

The coal consumption of the complete installation of the proposed plant at an average of three-quarters load without tar recovery would be about 119,500 tons per annum.

As the removal of the tar decreases the heat value of the gas, extra fuel should be allowed for. As the amount of tar in Saskatchewan lignite is comparatively small, 10 per cent will be allowed, making a total of 131,500 tons per annum, which on the Dudley Port basis would produce:—

Tar.	11,150 tons per annum.
Sulphate of ammonia.	4,780 tons per annum.

Reducing this on the above basis for the apparent lower proportion of by-products in the the local lignites, we have:—

$$\text{Tar, } 11{,}150 \times \frac{85}{170} = 5{,}550 \text{ tons per annum.}$$

$$\text{Ammonia, } 4{,}780 \times \frac{1\cdot05}{1\cdot16} = 4{,}330 \text{ tons per annum.}$$

Tar.—The present (February, 1913) price of coal tar in Montreal is $4.50 per barrel of 40 gallons, weighing about 500 pounds.

$$\frac{5{,}550 \times 2{,}000}{500} \times \$4.50 = \$99{,}900 \text{ per annum.}$$

Sulphate of Ammonia.—The present price (February, 1903) in Toronto is $65 per ton net. The market, however, is said to be a fluctuating one and the price varies a little according to quality of the product. The figure of $60 per ton is therefore taken.

4,330 tons x $60 = $259,800 per annum.

Total by sale of by-products.—$359,700 per annum, less expenses.

In any consideration of the value and sale of such by-products it must be remembered that the plant in question would probably not reach a size to justify installing recovery plant for say ten or fifteen years hence, by which time the local population would be much greater and the need of sulphate of ammonia as a fertilizer will probably be making itself felt.

1 An Investigation of the Coals of Canada, vol. 2, 1912, Department of Mines, Ottawa.
2 Bulletin 13, United States Bureau of Mines.

PRODUCER GAS PLANT ON THE COAL FIELD.

Complete Installation with By-product Recovery.

Maximum load, 13,000 B.H.P. Average load, 9,750 B.H.P.
One spare unit of 3,600 B.H.P. = 28 per cent reserve.

Capital cost—

Two 2,600 B.H.P. gas electric seats, as before	$224,000
Gas producers for 6,000 B.H.B.	90,000
Three 3,600 B.H.P. gas-electric sets	410,000
Gas producers for 13,500 B.H.P.	176,000
Complete equipment for ammonia and tar recovery	107,500
Coal and ash conveyors, bunkers, crane	24,400
Buildings and foundations	177,500
	$1,209,400
Engineering and contingencies, 7½ per cent	90,700
	$1,300,100
Interest during construction, 5 per cent	65,000
	$1,365,100

Per B.H.P. installed, $\frac{\$1,365,000}{16,000} = \$85.$

Per K.W., $\$85 \times \frac{1,000}{746} \times \frac{100}{92} = \$124.$

Annual cost—

		$	Per cent.
Capital charges, 13 per cent on $1,209,400, 8 per cent on $155,700		169,450	39·50
Fuel, power only, 85,400,000 B.H.P. hours at 2·80 pounds per B.H.P. hour	$119,500		
Fuel, extra if tar recovered, 10 per cent	11,950		
		131,450	30·50
Labour, power production only		35,000	8·13
Oil, waste and supplies		38,400	8·91
Repairs and maintenance, 3 per cent		36,280	8·42
Management, office and general		20,000	4·64
		$430,580	100·00

(Per B.H.P. hour, ·505; per K.W.H., ·735).

By sale of by-products as per preceding calculation, $359,700; discount this 35 per cent for cost of acid, extra labour and cost of marketing	$233,800
Net cost	$196,780

Per B.H.P. hour, $\frac{\$196,780}{84,500,000} = 0·232$ cents.

Per K.W.H., 0·34.

Per B.H.P., year of maximum demand—

$\frac{\$196,780}{13,000} = \$15.15.$ Year, $22.

Per 1,000 cubic feet of gas generated—

$\frac{\$196,780 \times 100}{131,450 \times 2,000 \times 40} = 1·88$ cents.

See following pages as to cost of transmission and operating sub-station at pumping plant, and pages 155 and 156 for total cost with producer gas including transmission and pumping.

In support of these estimated costs it may be stated that the Power Gas Corporation, Limited, of 39 Victoria Street, London, England, claim (1) that a large recovery plant in continuous operation can produce at less than 1 cent per 1,000 cubic feet of gas, and that the total works cost per K.W. hour sold, with slack at $1 would be 0·188 cents. Adding 13% for annual capital charges this would be 0·212 cents per K.W. hour sold.

At Messrs. Brunner, Mond and Company's works in Cheshire, England, the fuel cost with continuous running has worked out at 0·096 cents with slack at $1.70 delivered. This equivalent to 0·057 cents per K.W. hour with coal at $1, for fuel only.

Mr. Leonard Andrews (2), managing director of the Key Engineering Company, gives the total costs with a 16,000 k.w. plant, including 10 per cent interest and depreciation at 0·27 cents per K.W. hour.

Cost of Transmission Lines.

The two established sources of coal nearest to the proposed pumping station are at Lake of the Rivers (Consumer's Coal Company, which see) and in the Estevan district. Coal is known to exist at nearer points, as at Outlook on the C. P. R., but no very definite information is at hand as to quantity and quality.

The distance from Lake of the Rivers to the South Saskatchfiewan river, near Bryceton, is about ninety-five miles in an air line; allowing 10 per cent for deviations and contours, say 105 miles. The distance from Estevan in a similar manner would be about 245 miles.

It may be presumed that it would be desired:—

(1) To build a line of the best permanent construction.

(2) To provide two circuits as security against interruption of supply.

Capacity.—The electrical power required to be delivered at the pumping station would be for: 20,000,000 gallons capacity per day—1,600 k.w. (average load assumed 15,000,000 gallons = 1,200 k.w.) 100,000,000 gallons capacity per day—8,000 k.w.

Assuming as above, 105 miles transmission from the mines at lake of the Rivers, it would require a No. 0000 B. and S. aluminum wire to transmit 8,800 k.w. (8,000 plus 10 per cent margin) at 88,000 volts (80,000 at receiver end) with about 5 per cent loss.

It is however questionable whether it would be advisable to instal at first for such a distant future as the full requirements.

If we take three times the initial requirement of 1,600 k.w., i. e., 4,800 k.w., the power could be transmitted by a No. 0 aluminum wire and the total difference in cost with aluminum at 23 cents per pound would be $75,000 or about 12 per cent of the total cost of the line.

As, however, this is but a small percentage on the total cost of the complete undertaking, and to change the wire with the plant in operation would involve considerable expense, it will be assumed that the line is built of full capacity in the first place.

Right of way.—To purchase a 66-foot right of way at $20 per acre with legal expenses, fencing, etc., would cost about $350 per mile, but it may be anticipated that this could be considerably reduced by obtaining easements only over cross-country portions and that an average cost of $200 per mile will be sufficient to allow in the estimates.

(1) *Electrical Times*, London, May 28, 1903.
(2) *Electrical Review*, London, October 25, 1907.

Steel Tower versus Pole Line.

A double circuit steel tower line for 88,000 volts, of the best construction, would cost about as follows:—

Material and erection, per mile	$5,300
Engineering and contingencies, 10 per cent	530
Right of way, easements and fencing	200
	$6,030

A single circuit wood pole line of the best construction would cost about:—

Material and erection, per mile	$2,500
Engineering and contingencies, 10 per cent	250
Right of way, etc	200
	$2,950

As two single circuit pole lines would be required to give proper security against breakdowns it will be seen that the cost would be nearly equal. Two single circuit pole lines will usually give greater security against interruption than a double circuit steel tower line, but for the voltage required it is doubtful if a pole line would be as satisfactory as a steel tower line. Furthermore, the depreciation and maintenance on a pole line are so much higher than a steel tower line that the latter would, under the circumstances, be decidedly the best investment. A wooden pole line is therefore not further considered.

Transmission from Estevan.—The foregoing has been based on a line from the lake of the Rivers, a distance of 105 miles. The distance from the Estevan district, with 10 per cent margin for deviations, etc., would be about 245 miles. To transmit the same amount of power with about the same loss would then require 110,000 volts with a No. 0000 copper wire. This would involve higher cost per mile for wire and towers in addition to the increased mileage, and also higher cost for transforming and switching apparatus.

COST OF TRANSMITTING POWER FROM LAKE OF THE RIVERS STEEL TOWER LINE. 88,000 VOLTS. 105 MILES.

Initial Installation.

Maximum load, 1,600 k.w. Average load, 1,200 k.w.

Capital cost—

Tower line complete at $5,300 per mile	$556,000
Right of way, easements and fencing at $200 per mile	21,000
Two 1,780 k.w. step up transformers and switching equipment at power station with extra building space	24,920
Ditto at pumping station	24,920
	$626,840
Engineering and contingencies, 10 per cent	62,680
	$689,520
Interest during construction, 5 per cent	34,470
	$723,990

Per K.W. delivered, $\frac{\$724,000}{1,600} = \$450.$

(Includes transformers, switching equipment and buildings at both ends of the line.

	$	Per cent.
Annual cost—		
Interest, 5 per cent; sinking fund (25 years), 3 per cent		2·75
Repairs and maintenance, 5 per cent; taxes, 1 per cent		13·75
Capital charges, 13·75 per cent on $626,840, 7·75 per cent on $97,150	93,520	88·20
Patrolling the line at $80 per mile	8,400	7·92
Loss of power in transformation and transmission, say 5 per cent on 1,263 k.w. at 75 cents per k.w.h	4,130	3·88
	$106,050	100·00

Per K.W.H. delivered, $\frac{\$106,000}{1,200 \times 8,760} = 1{\cdot}01$ cents.

Complete Installation.

Maximum load, 8,000 k.w. Average load, 6,000 k.w.

Capital cost—		
Tower line, as before		$556,000
Right of way, as before		21,000
Two 1,780 k.w. transformers, etc	$24,920	
Four 2,000 ditto (1 spare) complete with switching equipment, etc	56,000	
		80,920
Ditto at pumping station		80,920
		$738,840
Engineering and contingencies, 10 per cent		73,880
		$812,720
Interest during construction, 5 per cent		40,636
		$853,356

Per K.W. delivered, $\frac{\$853,400}{8,000} = \$107$.

(Includes transformers, switching equipment and buildings for same at both ends of line.)

	$	Per cent
Annual cost—		
Capital charges,, 13·75 per cent on $738,840, 7·75 per cent on $114,520	110,360	73·3
Patrolling line	8,400	5·6
Loss of power, 7½ on 6,490 k.w. at .75 cents	31,900	21·1
	$150,660	100·00

Per K.W.H. delivered, $\frac{\$150,660}{6,000 \times 8,760} = 0{\cdot}286$ cents.

Note.—The costs per k.w. of capacity and per k.w. hour are very high on this line, owing to its being of first-class construction and equipped for two circuits and yet carrying only 8,000 k.w. If a similar line was constructed to carry say 20,000 k.w. and the balance distributed for general power purposes, the cost per k.w. would be greatly reduced.

ELECTRICALLY OPERATED PUMPING STATION.

The following estimate considers centrifugal pumps driven by electric motors, operated by power transmitted from a producer gas plant situated on the coal field, the pumping station then being practically a sub-station of the producer plant.

The cost of transformers, switchgear and buildings for same and the loss in transmission and transformation is allowed for under 'Cost of Transmission.'

The cost of 'Management, Office and General' is included under the cost of operating the producer gas plant, in which the cost of a mechanic is also included.

In considering the apparently high comparative cost of power from producer gas, it must be remembered that in this case this cost covers two separate buildings, plants and operating staffs and a long and expensive transmission with losses in transmission and transformation, placing it under a great disadvantage with water power generated on the spot where it is required.

ELECTRICALLY DRIVEN CENTRIFUGAL PUMPS OPERATED FROM PRODUCER GAS PLANT ON THE COAL FIELD.

Two 20,000,000 gallon units, one being reserve.

Initial Installation.

Capital cost—	
Two electric motor driven centrifugal pumping units	$ 41,900
Accessories, rough labour for erection of sets, etc.	5,000
Buildings and foundations	16,850
Cribs, conduits, wells and piping inside station	50,000
	$113,750
Engineering and contingencies, 15 per cent	17,050
	$130,800
Interest during construction, 5 per cent	6,540
	$137,340
Annual cost—	
Capital charges, 11 per cent on $113,750, 8 per cent on $23,590	$ 14,390
Labour	7,530
Oil, waste and supplies	500
Repairs and maintenance, 2 per cent	2,340
	$ 24,760

(*Re* management, transformation, etc., see preceding notes.)

Complete Installation.

Capital cost—	
Two 20,000,000 gallon units as before	$ 41,900
Three 30,000,000 gallon units	88,200
Accessories, rough labour for erection of sets, etc.	12,000

Buildings, foundations and crane	28,004
Cribs, conduits, wells and piping inside station	75,000
	$245,100
Engineering and contingencies, 7½ per cent	18,380
	$263,480
Interest during construction, 5 per cent	13,170
	$276,650

Annual cost—

Capital charges, 11 per cent on $245,100, 8 per cent on $31,550	$ 29,520
Labour	8,340
Oil, waste and supplies	1,200
Repairs and maintenance, 2 per cent	4,900
	$43,960

(*Re* Management, transformation, &c., see notes preceding initial installation.)

TOTAL COST WITH PRODUCER GAS PLANT.

Initial Plant.

Capital cost—

Producer plant on coal field (page 146)	$473,800
Transmission of power (page 152)	724,000
Pumping plant (electric) (page 154)	137,300
Total capital cost	$1,335,100

Per W.H.P. required $\frac{\$1,335,000}{2,750} = \$485.$

Per B.H.P. required, $\frac{\$485 \times 75}{100} = \$364.$

Annual cost—

Producer gas plant (page 147)	$126,000
Transmission of power (page 153)	106,100
Pumping plant	24,800
Total annual cost	$256,900

Per B.H.P. hour, $\frac{\$256,900}{12,050,000} = 2 \cdot 13$ cents.

Per W.H.P. hour, $\frac{2 \cdot 13 \times 100}{75} = 2 \cdot 84$ cents.

Per W.H.P. year, $\frac{\$256,900}{1,375} = \$187.$

Per 1,000 gallons delivered on height of land—

75 per cent of 20,000,000 gallons = 15,000,000 gallons per day.

Annual cost, $256,900 = $705 per day.

$\frac{\$705}{15,000} = 4 \cdot 69$ cents.

Complete Plant.

Capital cost—

Producer plant on coal field (page 150)	$1,365,100
Transmission of power (page 153)	853,400
Pumping plant (electric) (page 155)	276,700
Total capital cost	$2,495,200

Per W.H.P. required, $\frac{\$2,495,200}{8,950} = \$278.$

Per B.H.P., $\frac{\$278 \times 75}{100} = \$209.$

Annual cost—

Producer gas plant (page 150)	$196,800
Transmission of power (page 153)	150,700
Pumping plant (page 155)	44,000
Total annual cost	$391,500

Per W.H.P. hour, $\frac{\$391,500}{60,200,000} = 0{\cdot}65$ cents.

Per B.H.P. hour, $\frac{0{\cdot}65 \times 100}{75} = 0{\cdot}865$ cents.

Per W.H.P. year, $\frac{\$391,500}{6,875} = \$57.$

Per 1,000 gallons delivered on height of land—

$\frac{\$391,500}{365 \times 75,000} = 1{\cdot}42$ cents.

PRODUCER GAS VERSUS WATER-POWER.

It will be seen from the summary on pages 128 and 129 that the estimates show a high cost for producer gas power, higher than any of the alternatives, and that the water-power without steam reserve shows the lowest cost per horse- power year except for the initial installation.

The estimates, however, have been prepared to meet a particular case and not as a general comparison.

To meet this case the producer gas power has to be transmitted about 100 miles to compete with water-power to be used at the spot where it is developed, and directly applied without conversion.

This transmission of the gas power involves in this case a double circuit steel tower line of the best construction to carry a comparatively small amount of power, involving a high cost per horse-power year.

Furthermore, the producer gas estimate, as a complete estimate for the purpose, includes the cost of transforming stations at both ends of the line and all losses, of two separate buildings and plants (power plant and pumping plant) and two staffs for operating the same.

The water-power and other plants are not burdened with these costs, though the water-power plant has a very expensive dam.

The estimates must therefore not be taken as an indication of the ability of producer gas to compete under any other conditions.

The cost by water and gas at the respective spots where the power is generated is, according to the estimates, for a complete installation:—

Producer gas, per B.H.P. year	$15·15
Water-power, no steam reserve per B.H.P. year	20·70
Water-power, with steam reserve per B.H.P. year	26·30

It is of interest to consider, further, how the comparison would stand if the case was reversed and the water-power had to be transmitted under the same conditions to compete with producer gas where it is produced.

To make such a comparison properly and fairly, the size of the water-power plant would have to be increased to allow for transformation and transmission losses and the size of the gas plant correspondingly reduced.

This would involve preparing new estimates, and as it is not an actual case does not justify the detail, but a rough idea may be obtained by adding the costs per B.H.P., due to the transmission, transformation, line losses and extra plant and staff, to the water-power cost instead of to the producer gas cost.

This gives the following result:—

	Producer gas on the coal field.		Water Power Transmitted (without steam reserve).	
	Initial.	Complete.	Initial.	Complete.
Capital cost per B.H.P. installed...	$91	$85	$804	$248
Cost per B.H.P. year..............	49	15	150	41
Cost per B.H.P. hour..............	0·74c.	0·23c.	2·28	0·62c.

This comparison, again, holds good only for this size of plant operating on this load factor (about 75 per cent), but it is sufficient to indicate that if power was required at a point to which either power would have to be transmitted, the case would have to be considered on its merits.

PURCHASE OF POWER.

An alternative that might be considered is the purchase of electric or other power by the proposed Commission, delivered 'in bulk' at their pumping station on the South Saskatchewan river.

Such a course would relieve the Commission of a large part of the capital expenditure and of the operation of a generating station, but still leave in their hands the operation of the pumping plant and the distribution of the water.

In other words a power supply company could be organized and capitalized by private interests to develop power, say on one of the proved coal fields, and transmit the same electrically to the Commission's pumping station, delivering it ready for use at a fixed rate per horse-power year under a contract for a term of years.

If such a company were formed it may be presumed that it would also wish to undertake the supply of light and power to all municipalities and power users within their sphere or practical radius of transmission, who desired it, and would thus fill a general public need.

Large numbers of companies are now in successful operation on such lines. No such company is, so far as is known, yet formed in the area under consideration, though the opportunity, even without the water-pumping project, is obvious.

A usual preliminary to the securing of capital and flotation of such a company is the obtaining of definite advance contracts for the sale of their product (power).

There can be little doubt that if the Commission announced that they were prepared to consider offers and gave sufficient time for receiving tenders, competitive bids could probably be obtained.

Such a tender would be on the basis of something like 2,000 horse-power of 24 hour power, increasing, over a term of years, to say 5,000 horse-power, and possibly to 10,000 horse-power, or more.

Assuming that a preliminary syndicate of undoubted standing was formed and secured a provisional contract with the Commission for such a supply, there can be little doubt that they could secure other considerable contracts with municipalities and large power users in the same district.

They would then be in a position to start with a plant of sufficient size to secure the most economical production possible and with a large load secured by long term contracts. Under such conditions there would be no difficulty in financing a company to put in a plant of the best modern construction with every necessary safeguard.

Assuming the source of power to be coal, such a company could secure its own coal lands or enter into contracts for the supply of coal at fixed rates over a term of years.

It is not to be lost sight of, that such a contract with the proposed Commission would in itself make possible the formation and capitalization of a company; that it would for financial purposes be on a par with obtaining a good franchise and would make a starting point for the company to obtain other contracts; and that, therefore, it would be worth the while of a company to make a special low price to the Commission.

The Commission would safeguard itself by providing for:—

(1.) The plans and plant to be approved by its own engineers.

(2.) Adequate spare plant and duplicate transmission lines.

(3.) Precedence as to supply in the event of interruption or diminution of supply from any cause.

(4.) A sliding scale of charges depending on the amount of power taken each year during the life of the contract.

(5.) The option of renewing the contract at prices to be determined by arbitration.

(6.) Compulsory acquisition of the plant in case of bankruptcy or wilful default (as in the contract of the Hydro-Electric Commission of Ontario).

(7.) Their own resident inspector at the generating station (if found necessary), etc., etc.

There is usually a natural desire on the part of any public body undertaking a public utility to keep the whole thing in their own hands and under their own control.

There are, however, numerous instances in Canada and other countries of municipal and other public bodies taking all or part of their power supply 'in bulk' from a company and carrying out the distribution themselves. Some examples are given in the Table on page 161.

In Ontario, as is well known, many municipalities take their supply from the Hydro-Electric Commission of Ontario and carry out the distribution themselves. The Hydro-Electric Commission themselves purchase 'in bulk' from a private company and act as intermediaries, and the municipalities have no control over the power station.

In the case under consideration it may be anticipated that a strong and reliable company could be formed with ample capital and the best and most modern of plant provided, and in such case there is no inherent reason why the supply of power to the pumping station should not be just as satisfactory and secure against interruption as if the Commission operated their own generating station.

The Commission would have the advantage of reducing capital expenditure and of knowing in advance exactly what the power would cost. This would be of assistance in determining closely the tariff rates to be charged for water.

Such a contract would probably have to be made for a minimum term of 21 years, with the option to the Commission of either renewing at a price to be fixed by arbitration, or of terminating and constructing their own generating station, or of taking supply from some other company who offered better terms.

A public power company should naturally be in a better position to generate power cheaply than an individual user such as the proposed Water Board. The pumping

load is in itself, owing to the continuous and steady demand, a load favourable to low cost of production, and if a power company had such a load in addition to the ordinary load for power and lighting, they would be in an exceptionally favourable position.

The advantages to a power company when such a customer is only one of a number of customers are many. For instance:—

(1.) They can instal a larger plant, giving lower capital cost per horse-power installed and obtain a higher efficiency due to larger units.

(2.) Their administration charges are spread over a larger output.

(3.) Their wages bill is but slightly increased for the larger output.

(4.) Their transmission lines can carry power for other customers, leaving only a part of the cost to be charged against pumping load.

(5.) Their operations are on a large enough scale to make the recovery and sale of by-products from fuel practicable at an earlier stage.

As an alternative to purchasing power per horse-power year, in which case the cost usually depends more on the maximum temporary load occurring in a given period than on the actual work done, a contract might be made to pay at a certain rate per 1,000,000 gallons actually pumped.

For instance, it is stated [1] that the city of Minneapolis received an offer from the Minneapolis General Electric Company to supply power from its hydro-electric plant for pumping city water at the rate of $3.63 per 1,000,000 gallons pumped, or 0·363 cents per 1,000 gallons. This was for a plant of two 20,000,000 gallon units pumping against a head of 247 feet, a very similar plant to that herein considered.

To give another instance of possibilities in this direction, the offer of Mr. A. S. Porter, of Regina, made in writing on November 28, 1912, may be mentioned.

Mr. Porter appears to own a controlling interest in 17,000 acres of coal lands in the Estevan district shown on map (Plate 38), and has for some time past been endeavouring to form a company to supply power by electric transmission to Regina, Moosejaw, etc. Estimates on cost of production and transmission have, he states, been prepared for him by a firm of engineers in Winnipeg.

Basing his figures on these estimates, he made a tentative offer to deliver power for pumping at the Elbow at $33.75 per electrical horse-power per year of 300 days, including transformation to the required pressure at the delivery end. Assuming 15 per cent extra cost for a full year the cost would be $38.80 per electrical horse-power year.

Now, assuming that the proposed Water Commission had only to instal an electric pumping station to receive the power ready for use at the above rate, the cost would work out about as follows:—

ELECTRICALLY DRIVEN CENTRIFUGAL PUMPS OPERATED WITH PURCHASED POWER.

Initial Installation.

Two 20,000,000 gallon units, one being reserve.	
Capital cost, as detailed on page 154	$137,340
Annual cost—	
As detailed on page 154	24,760
Purchase of power at $38.80 per E.H.P. year. Combined efficiency motors and pumps, 69 per cent—	
$\$38.80 \times \frac{100}{69} \times 1,375$ W.H.P.	77,500
Management, office and general.	12,000
	$114,260

[1] *Electrical World*, New York, Dec. 1, 1910, page 1303.

Complete Installation.

Two 20,000,000 gallon units. Three 30,000,000 gallon units.
Capital cost, as detailed on page 155 . . . . $276,650

Annual cost—
As detailed on page 155 . . . . $ 43,960
Purchase of power as above—
$\$38.80 \times \frac{100}{69} \times 6{,}875$ W.H.P. 387,000
Management, office and general. 20,000

$450,960

These figures are shown in the comparative summary on pages 128 and 129, and the results may be condensed thus:—

Source of power.	Total cost per 1,000 gallons pumped, in cents.	
	Initial.	Complete.
Steam turbines and coal	2·26	1·66
Water-power	2·78	0·69
Water-power with steam reserve	3·05	0·86
Purchased power at $38.80	2·09	1·65

From which it will be seen that purchased power even at this high price would offer considerable advantage in total cost of pumping in the early stages, but that water-power would have a large advantage when the complete plant was in operation—which might be 25 years, or more, hence.

The striking difference, however, is in capital expenditure, which compares thus—

Source of power.	Initial Plant.	Complete Plant.
	$	$
Steam turbines and coal	257,000	656,000
Water-power	1,448,000	1,652.000
Water-power with steam reserve	1,569,000	1,945,000
Purchased power	137,300	277,000

Furthermore, the above example is based on the transmission of power from the Estevan district, about 220 miles. If the transmission was from the Lake of the Rivers district (about 100 miles) or possibly some nearer point, the cost should be considerably reduced.

It is also probable that on competitive tenders a much better price per horse-power year could be obtained than that which has been here used.

As further examples of the supply of electric power 'in bulk' on a large scale, the following recent instances may be mentioned.

The Third Avenue Railway Company of New York have entered into a contract with the New York Edison Company to take from that company all the energy

required for operating its lines, and this contract includes turning over to the Edison Company the Railway Company's 40,000 horse-power generating station. ([1])

The Chicago, Milwaukee and St. Paul Railway Company have entered into contracts with the Great Falls Power Company and the Thompson Falls Power Company to take energy for operating 450 miles of its lines. These contracts are for 99 years and 20,000 k.w., with options on additional energy to the amount of 30,000 k.w. ([2])

In conclusion of this section it may be remarked that if the proposed Water Commission themselves undertook the distribution of power for general purposes, they would have all the potential advantages of a large power company, but they would incur very large capital expenditure and they would not necessarily secure as good economic results as a company operating for profit and giving its whole attention to the production of power.

CANADIAN CITIES TAKING SUPPLY IN BULK FROM PRIVATE COMPANIES.

City or Town.	Population.	Length of Transmission.	Approx. Price per H.P. year.	Power Supplied by.
		Miles.	$	
Fort William	17,500	16	25	Kaministiquia Power Co. 1,450 H.P.
Port Arthur	11,200	17		Kaministiquia Power.
Calgary	44,000	50	29	Calgary Power Company.
Grand Forks, B. C.	1,600	50		West Kootenay Power & Light Co.
Hamilton, Ont.	82,000	35		Dominion Power & Transmission Co.
Ottawa	86,000		15	Ottawa & Hull Power M'f'g Co.
Montreal	562,000		20 to 35	Montreal Light, Heat & Power Co.
Westmount, Que.	16,000		23.80	Montreal Light, Heat & Power Co.
Lachine, Que	11,200		32	Montreal Light, Heat & Power Co.
St. Lambert, Que.	3,500		32	Waterman Fountain Pen Co.
Longueuil, Que	3,900		30	Montreal Light, Heat & Power Co.
Joliette, Que	5,300			Shawinigan Water & Power Co.
Valleyfield, Que.	10,000			Montreal Cotton Co.
Niagara Falls	4,500			Ontario Power Co.

OIL ENGINE PLANT.

Under this heading the only engine to be considered is that of the Diesel type, since no other type of oil engine appears to be at present made in sufficiently large sizes. The Diesel engine is, however, made by many different firms in Europe and by at least one firm in the United States, the latter, however, only making in sizes up to 450 B.H.P.

These engines are now so well known and their reliability and economy have been so fully proved both for stationary work and for marine work by the British, French and Japanese navies, that it is not deemed necessary to enlarge on these points.

As an instance of their use for pumping, it may be mentioned that a 200 horse-power engine was installed by the Manchester Ship Canal Company in 1907, this engine giving an output at the rate of 31,700,000 gallons per 24 hours against a head of 13 feet. Since that date two other similar plants have been installed by that company at other locks.

[1] *Electrical World.* August 3, 1912, page 231.
[2] *Electrical World.* March 22, 1913.

The following table shows some of the Diesel engines in operation or on order for use in Canada:—

DIESEL ENGINE PLANTS IN CANADA.

Locality.	Number of Engines.	Brake Horse Power.		
		In Operation	On Order.	Total.
Town of Yorkton, Sask.	2	150	500	650
" Scott, Sask.	1	100	....	100
" Wilkie, Sask.	1	....	100	100
" Battleford, Sask.	2	....	480	480
" Melfort, Sask.	1	....	150	150
" Vernon, B.C.	1	....	200	200
" Penticton, B.C.	1	....	200	200
Saskatchewan Clay Products Company.	1	....	150	150
The Electric Company, Toronto	1	....	600	600
Moosejaw Electric Railway Company	3	400	500	900
	14	650	2,880	3,530

It will be noticed that both the town of Yorkton and the Moosejaw Street Railway Company have placed repeat orders.

The power for the Moosejaw Street Railway is provided entirely by Diesel engines, and, as shown above, the plant consists of three engines totalling about 900 horse-power. This plant was designed and installed under the advice of Mr. J. B. McRae, consulting engineer, of Ottawa, and as a result of personal inspection and inquiries it may be stated that it has given unqualified satisfaction to all concerned.

Up to a comparatively recent date these engines were only made up to about 500 B.H.P., but the size is being continually increased. Engines of 2,000 horse-power are now in use in Switzerland ([1]) and it is expected to construct them of 1,000 and possibly 2,000 horse-power per cylinder. Messrs. Carel Frères, of Ghent, Belgium, make in sizes up to 6,000 horse-power. A British firm is stated to have recently secured an order for four 4,000 horse-power Diesel engines in competition with tenders for steam turbines ([2]), but under British conditions these engines are not burdened with the cost of Customs duty and excessive freight, as in Saskatchewan, and the cost of oil in London, England, is about 4 to 8 cents per gallon as against 14 or 15 cents in Saskatchewan. The freight is excessive for a long haul as the weight of the engines alone, owing to the thickness of metal required for the high pressures used, is usually greater than the combined weight of steam turbines and boilers.

These engines have conspicuous advantages in simplicity compared to a complete steam installation, there are no boilers required and no stand-by losses, and the buildings and labour required are both less than for steam.

On the other hand, the capital cost of the engines is high, very heavy foundations are required and it is widely but not universally considered that owing to small clearances, fineness of the valves and their adjustments, etc., more skilled attention is necessary than with steam engines. Opinions on this point, and on that of depreciation compared with steam engines, appear to be about equally divided.

As to economical performance, there is no question that with cheap fuel oil Diesel engines will give so good a performance that it will in many cases more than off-set the comparatively high capital cost and give better results than can be obtained from other sources of power—especially is this the case with small powers and intermittent loads.

[1] Jour. Inst. E.E. London, Eng., Sept., 1912, p. 618.
[2] Technical Paper 9, Bureau of Mines, Washington, 1912.

When, however, there is a combination of:—

(1) Fairly large plant,
(2) High capital cost,
(3) Excessive cost of fuel oil,
(4) Steady 24 hour load,

as in the case under consideration, it does not appear that this power can offer as good results, expressed as total annual cost, including capital charges, as either water-power or steam (see summary on pages 128 and 129 and detailed estimates).

Very careful consideration has been given to this matter on account of the many advantages possessed by Diesel engines. The detailed working results obtained from several plants have been closely analysed and adapted as to price of oil, labour, etc., to meet the conditions required, but the result is in every case unfavourable for these particular conditions.

For example, take a municipal plant in the eastern United States, which consists of about 950 B.H.P. of Diesel engines in continuous operation and giving very good results, the cost of oil being equivalent to 3·48 cents per Imperial gallon.

An analysis of the working results shows that if this plant had been operating a pumping load with oil at 15 cents, the total cost would have been $115 per water horse-power year, or 28 per cent more than the cost estimated for steam turbines (see summary, pages 128 and 129).

On the other hand, if this same plant could have been put down in Saskatchewan and operated on fuel oil at 3·48 cents the cost would have been 32 per cent less than with steam.

At a recent date (Dec., 1912) the price of fuel oil in tank car lots at Elbow would have been 14 cents; it has been as high as 15 cents in Moosejaw, and it would not be safe to assume less than this for estimating purposes; owing mainly to the reported decision of the Standard Oil Company to supply no more crude oil, but to refine the whole of their product, the market in Western Canada has been much disturbed and the future price appears to be a very uncertain quantity.

It is therefore possible that an oil engine plant in Saskatchewan might be rendered practically valueless by an increase in the price of fuel oil that would make the cost of operation uneconomical as compared with other sources of power, or even prohibitive.

The above, however, by no means exhausts the possibilities with reference to fuel oil. So far only imported crude petroleum at 15 cents per gallon has been considered. There are other liquid fuels, nearly or equally as suitable, if they can be obtained in large enough quantities at a low enough price.

It will be seen from Fig. 5 that with fuel oil at less than 6·3 cents, or thereabouts, the cost of production with Diesel plant would be lower than with steam for the conditions required.

Diesel engines are claimed to work satisfactorily and economically, and without any important alteration or adjustment, on a wide variety of oils, including shale oils, gasworks tar oil, creosote oil, and in fact on almost any combustible oil.

In respect to shale oil, this is extensively used as fuel oil in Great Britain and is stated to be lighter, cleaner and better for the purpose than crude petroleum. The price there is about 10 to 11 cents per gallon, but this is probably largely controlled by the price of crude petroleum.

No definite information appears to be available as to oil shales in Saskatchewan. The shales in southwest Saskatchewan are stated to carry no oil whatever, but oil shales are stated to exist north of Battleford, Saskatchewan, north of Edmonton, Alberta, and south of Manitou, Manitoba, and it would appear to be a matter worth investigation.

In 1908, some 45 tons of New Brunswick shales were sent to an oil shale works

in Scotland and there tested under practical conditions and under the superintendence of the Department of Mines, Ottawa. The report[1] states that:—

> 'The results were very satisfactory, as the average yield per ton of shale was 40·09 gallons of crude oil and 76·94 pounds of sulphate of ammonia. This compares very favourably with the shales which are worked so extensively in Scotland, the yield of which rarely exceeds 25 to 30 gallons of crude oil.'

Sulphate of ammonia is at present worth $60 to $65 per ton in Montreal, and assuming the residue oil was sold for even 5 cents per gallon, the gross return from a ton of shale, without taking account of the lighter and more valuable distillates, would appear to be about as follows:—

Crude oil, 40 gallons at 5 cents..	$2 00
Sulphate of ammonia, 77 pounds at $60 per ton	2 31
	$4 31

This, however, is a subject by itself. Much valuable detailed information as to the methods and cost of production of shale oil and by-products is contained in the reports above referred to, Nos. 55 and 1,107.

It is stated (2) that a noticeable feature i nthe growth of German industries is the rapidly increasing use of coal tar oil and residue for fuel in place of petroleum. The production from lignite and shale works amounts to some 60,000 tons annually, and the coke and gas works produce about 1,000,000 tons of tar annually, from which some 300,000 tons of heavy oil are obtained and used as fuel, the calorific value of which is very high. In consequence of the rapidly increasing production the cost of this oil, now averaging 5 cents per gallon, is becoming less.

It has been pointed out by Dr. Diesel (3) that the most economical way of using coal lies in the extraction of the tar or creosote oil. The two principal methods are: First, to coke at a low temperature giving a high yield of gas and a good oil, but inferior coke; second, to coke at a high temperature, producing good coke but a small yield of oil.

> 'In Germany, where the tariffs on crude oil are excessive, the coal is coked by an intermediate process, with some slight additions, and a good coke for furnace use is produced; a large yield of good heavy oil is obtained from the tar after the more valuable products have been removed.'

A report on the natural gas and oil in the western provinces, prepared by Mr. F. G. Clapp, chief geologist, Bureau of Associated Geological Engineers, Pittsburg, is understood to be in hand by the Department of Mines, Ottawa, and to be expected to be issued in a few months.

A Royal Commission on Fuel Oil is now sitting in Great Britain—with these and other expected reports it is probable that a good deal more information on these subjects should soon be available.

In view of the large amounts of easily-mined lignite in Saskatchewan from which oil and other by-products could be extracted, and of the possibility of oil or oil shales being developed within reasonable distance, it is possible that the position as to fuel oil may be considerably modified.

[1] Production of Natural Gas and Petroleum in Canada, No. 46, 1909. Bituminous or oil shales of New Brunswick and Nova Scotia, etc., Nos. 55 and 1,107, Department of Mines. Ottawa.

[2] Inst. of C.E. Abstracts. London, vol. CLXXXVI, page 46, 1911.

[3] The *Motor Ship and Motor Boat*, editorial, England, Oct. 31, 1912.

DIESEL OIL ENGINES.

Initial Installation

1,375 W.H.P. x $\frac{75}{100}$ = 1,830 B.H.P.

The rated capacity is reduced 8 per cent at Moosejaw altitude and a margin of 7 per cent should be allowed on account of small overload capacity; total, 15 per cent.

1,830 B.H.P., plus 15 per cent = 2,155 B.H.P.

Two units, one being reserve.

Capital cost—

Two 2,160 B.H.P. Diesel oil engines at $60	$ 259,200
Two 20,000,000 centrifugal pumps (very slow speed or gearing) at $9 x 1,830	32,900
Accessories, rough labour for erection, spares, piping, etc.	5,000
Buildings and foundations	11,880
Crane	6,000
Oil tanks for 90 days storage, excavation, pumps and piping	19,400
Cribs, conduits, wells and piping	50,000
	$384,380
Engineering and contingencies, 15 per cent	57,660
	$442,040
Interest during construction, 5 per cent	22,100
	$464,140

Per B.H.P. installed, $\frac{\$464,000}{4,320}$ = $107.

Per W.H.P., $\frac{\$464,000}{2,750}$ = $168.

Annual cost—

	$	Per cent.
Capital charges, 11 per cent on $384,380, 8 per cent on $79,760	48,670	27·40
Fuel oil, 12,050,000 B.H.P. hours, 0·45 pounds per B.H.P. hour, 15 cents per gallon	92,000	51·75
Labour	8,340	4·70
Lubricating oil, waste and supplies, 0·04 cents per B.H.P. hour, plus pumps	5,070	2·85
Repairs and maintenance, including buildings, cribs, wells, etc., 3 per cent	11,530	6·55
Management, office and general	12,000	6·75
	$177,610	100·00

Per B.H.P. hour, $\dfrac{\$177,600}{12,050,000} = 1\cdot47$ cents.

Per W.H.P. hour, $1\cdot47 \times \dfrac{100}{75} = 1\cdot96$ cents.

Per W.H.P. year, $\dfrac{\$177,600}{1,375} = \$129$.

Per 1,000 gallons pumped, $\dfrac{\$177,600}{365 \times 15 \text{ mil.}} = 3\cdot24$ cents.

Fuel.—Each 10 per cent difference in cost of fuel will make 5·2 per cent difference in total cost.

DIESEL OIL ENGINES.

Complete Installation.

Five units, total capacity 130 million gallons, of which 30 per cent is reserve.
Working capacity, 100,000,000 gallons = 6,875 W.H.P.
Total installed, 130,000,000 gallons = 8,950 W.H.P.

Capital cost—

Two 2,160 B.H.P. engines as before	$ 259,200
Two 20,000,000 gallon pumps as before	32,900
Three 3,230 B.H.P. engines at $60	582,000
Three 30,000,000 gallon pumps at $8.50 x 2,750 B.H.P.	70,000
Accessories, labour, spares, piping	12,500
Buildings	25,900
Crane	6,000
Oil tanks for 90 days storage, pumps, piping, excavation	97,000
Cribs, conduits, wells and piping	75,000
	1,160,500
Engineering and contingencies, 7½ per cent	87,100
	1,247,600
Interest during construction, 5 per cent	62,380
	$1,309,980

Per B.H.P. installed, $\dfrac{\$1,309,980}{14,010} = \$93.50$.

Per W.H.P., $\dfrac{\$1,309,980}{8,950} = \$146$.

Annual cost—

	$	Per cent.
Capital charges, 11 per cent on $1,160,500, 8 per cent on $149,480	139,850	21·73
Fuel oil, 60,250,000 B.H.P. hours. 0·4 cents per B.H.P. hour, 15 cents per gallon	408,000	63·48
Labour	18,230	2·82
Lubricating oil, waste and supplies (0·035 cents per B.H.P. hour for engines)	22,350	3·46

COMPARISON OF

OIL ENGINE AND STEAM TURBINE PLANT.

TOTAL ANNUAL COST OF OPERATION INCLUDING CAPITAL CHARGES WITH FUEL AT VARYING PRICES.

ILLUSTRATING ONLY THE PARTICULAR CASE CONSIDERED.

NOTE: IT WILL BE SEEN THAT THE TOTAL ANNUAL COST IS THE SAME WITH COAL AT \$5·65 & OIL AT 6·3 CENTS BUT THIS IS LARGELY DUE TO DIFFERENCE IN CAPITAL COST, \$257,000 FOR STEAM & \$464,000 FOR OIL.

INITIAL INSTALLATION

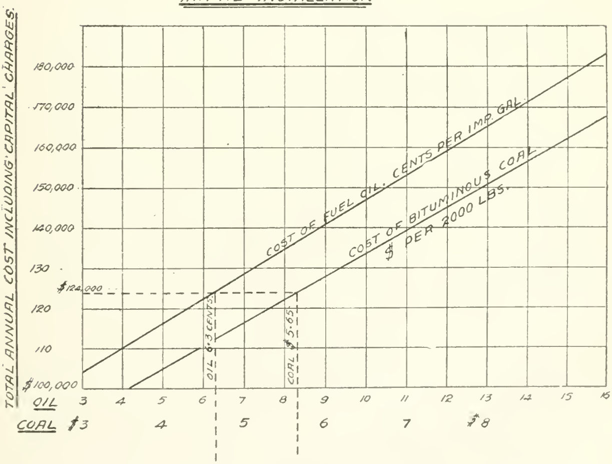

Fig. 5.

	$	Per cent.
Repairs and maintenance, including buildings, cribs, wells, etc., 3 per cent..	34,800	5·40
Management, office and general..	20,000	3·11
	$643,230	100·00

Per B.H.P. hour, $\frac{\$643,200}{60,250,000} = 1{\cdot}07$ cents.

Per W.H.P. hour, $1{\cdot}07 \times \frac{100}{75} = 1{\cdot}42$ cents.

Per W.H.P. year, $\frac{\$643,200}{6,875} = \$93.50$.

Per 1,000 gallons pumped, 2·35 cents.

Fuel.—Each 10 per cent difference in cost of fuel makes 6·3 per cent difference in total cost.

GAS ENGINES FOR PUMPING.

Further possible alternatives to those already given would be:—

(1) Producer gas plant at the river, with coal delivered by rail and gas engine driven pumps.

(2) Natural gas in gas engines. (Natural gas under boilers is considered on pages 134 and 137.)

Considering the first of these, if the power could then be directly applied, this would offer the advantages of:—

(1) Eliminating the cost of an expensive transmission line for conveying a comparatively small amount of power.

(2) Eliminating losses in transmission and in conversion at both ends of the line.

(3) Reduction in capital cost of gas producer and engine plant, as the size would be reduced by the saving of losses in transmission and conversion.

(4) Combining the power and pumping plants in one place with one staff. and the only question would be to compare the cost by this method with that of producing gas on the coal field and electric transmission of power.

There is some question, however, whether the power could be directly applied with satisfactory results for a pumping plant of this size and head. In small plants the gas driven pump appears to give good service, but its performance is not equally well established for large plants.

For instance in a recent paper, ([1]) Mr. Charles A. Hague, M.Am. Soc. C.E., states that:

> 'The gas engine as a water-works power is entirely undeveloped on anything like the scale which it will have to reach to be seriously considered in fairly large schemes of pumpage. . . . Developments along the line of gas power pumping for waterworks are going on, and good results in economical and reliable gas production, easy of manipulation, will be one of the improvements in the future not very far away. The large gas engine available for waterworks pumping has not yet come to the front, . . . the direct application of power with steam and the indirect application with gas, as expressed by a mechanical efficiency of 95 per cent for steam and 75 per cent for gas shows why the gas cannot compete in the larger units in the present day pumping plant until some more direct application of its power to pumping can be made.'

[1] The Present Day Pumping Engine for Water Works. Trans. Am. Soc. C.E., vol. LXXIV. December, 1911.

The Delaware Avenue fire pumping station in the city of Philadelphia is equipped with gas engines direct connected to triplex pumps and is reported (1) to have been in service for a number of years with great success. A second station was equipped with practically duplicate plant, consisting of ten 300 horse-power gas engines direct connected to triplex pumps. These, however, are small units operating on city gas with two sources of supply. Also, being for fire purposes, they are only used intermittently, and would have a considerable advantage over steam in the saving of standby losses.

Considering the second of the above alternatives, natural gas in gas engines, it may be said that gas engines of small and moderate size operate satisfactorily on natural gas, but that in this case also there is some question whether they would be wholly satisfactory and reliable in large units for direct connection to high lift pumps, as in the present case. It is understood that in the Pittsburg district it is sometimes preferred to burn the natural gas under boilers in preference to using it in gas engines, on account of the trouble caused by fine grit in the natural gas. This may be due to diminished pressure in the wells after long use making less back pressure necessary and so allowing the grit to rise with the gas.

This trouble does not seem to occur in the Medicine Hat district, but some of the larger gas engines there have not given satisfaction. It is worth noting in this connection that the new municipal power and pumping station at Medicine Hat is being equipped with gas-fired steam boilers and electrically driven centrifugal pumps, with the intention of using the existing gas engines as a stand-by only.

If the power of gas engines is not directly applied, but transmitted by belts or ropes or converted by generators or motors, the capital expenditure, operating and maintenance costs are increased, and the complication is increased, so that any advantages are largely discounted.

It would therefore appear desirable that it should be demonstrated, by the satisfactory operation of existing plants, that gas engines could be directly applied to pumps of similar capacity and operating under a similar head to that of the case in question before this alternative is fully considered.

REVIEW OF ALTERNATIVES.

The advantages and disadvantages of the foregoing alternative sources of power have been discussed and compared under the respective headings.

The principal points and considerations may now be briefly reviewed.

High duty pumping engines and steam turbines.—As between these the results appear to be so close that it would be desirable to re-examine the matter on new quotations for machinery, coal, etc., when the matter is ripe for decision.

Producer gas does not appear to offer a promising alternative under the particular conditions to be met, except with Humphrey internal combustion pumps.

Natural Gas.—It is uncertain whether this will be available, and at the price so far suggested it would offer no large saving.

Purchased power would probably offer very considerable advantages both in capital expenditure and cost per 1,000 gallons pumped, if obtainable under suitable conditions.

Oil engines.—Are high in first cost and at the present price of fuel oil do not appear to offer favourable results under the particular conditions to be met.

Water-power.—Involves very large capital expenditure, nearly the whole of which must be incurred when putting in the initial plant. The cost per 1,000 gallons pumped will be higher than with steam plant for a small output, but much lower than with steam plant for a large output.

(1) The *Canadian Engineer*, May 21, 1909.

Steam turbine plant offers the advantages of low first cost and reliability, with low cost per 1,000 gallons pumped compared to water-power for the first few years of operation, after which water-power would have the advantage.

Humphrey pumps (internal combustion), cannot yet be said to be fully proved as a commercial and engineering success, but the indications are that they probably soon will be, and this is a matter that should be further inquired into when the Humphrey plants now installed have had time to prove their qualities. Particular attention is called to the chapter on this pump commencing on page 115 elsewhere in this report.

Suggestions.—A vital point is that the initial demand will be small compared to the size of the scheme.

The purchase of power in bulk, at all events in the early stages, would, if possible on favourable terms, appear to offer very substantial advantages. The Humphrey pump should also be further considered.

Failing these, it appears that steam turbines would give the best results at first and water-power would give the best results when the demand was sufficiently large.

It would, therefore, appear to deserve careful consideration whether it would not be desirable to put in an initial installation of steam plant, and subsequently when the conditions warrant it, develop the water-power and secure the economy it would give under those conditions.

These conditions would be, assuming that sufficient water-power is available, that the actual ascertained demand for city water was sufficiently large to justify the extra expenditure on a $1,000,000 dam in order to secure low pumping costs.

The steam plant would be then retained as reserve or stand-by to the water-power plant and no part of the expenditure would be lost.

Such a course would involve but comparatively small expenditure on the power plant at first, and outside of the water-power question, would allow time for developments in respect to producer gas, location of coal in the vicinity, oil fuel, etc., which may change the situation considerably within the next few years.

Electric transmission versus freight on coal.

In most cases it is cheaper to transmit electric power than to convey coal, but in the case under consideration it seems necessary to instal an expensive double circuit line to transmit an amount of power that is comparatively small (for a transmission line to carry) even when the undertaking is complete, and very small in the early stages.

It will be of interest to ascertain separately, that is without including power plant, the cost of transmitting the required amount of power electrically and the cost of conveying the necessary amount of coal to produce the same amount of power, by rail from the same spot.

As the transmission line has been figured from the Lake of the Rivers district, 100 miles distant, the coal will be assumed to come from the same point. We will assume run of the mine coal at $1.60 per ton on cars, (page 114) and that this lignite, with large boilers, economizers and superheaters wil have an evaporative power of four pounds of water per pound of coal.

The steam turbine plant, which represents average results, would have a duty of 120,000,000 foot pounds of work per pound of steam.

The cost of freight on coal would be about as follows:

Initial plant.—The average demand for water is assumed at 75 per cent of 20,000,000 gallons per day, (page 109) or 625,000 gallons per hour. The head with pipe friction is taken at 328 feet.

$$\frac{625{,}000 \times 10 \times 328 \times 1{,}000}{120{,}000{,}000} = 17{,}100 \text{ pounds of steam per hour.}$$

$$\frac{17{,}100}{4 \times 2{,}000} = 2{\cdot}138 \text{ tons of coal per hour.}$$

$2{\cdot}138 \times 8{,}760 = 18{,}700$, plus 10 per cent $= 20{,}570$ tons per annum.

The freight on this (under conditions defined on page 106) would be approximately \$1.54 per ton, allowing double cost on the private branch line.

20,570 tons x \$1.54 = \$31,700 per annum.

Complete plant.—Increased coal in proportion to output.

$$\$31{,}700 \times \frac{75}{15} \text{(millions of gallons)} = \$158{,}500 \text{ per annum.}$$

Electric transmission.—The annual cost with a double circuit steel tower line (see pages 152 and 153), including transforming stations, losses, patrolling and right of way, is \$106,000 for the initial plant and \$151,000 for the complete plant.

The comparison, therefore, on the above basis, stands thus:—

—	Annual Cost.		Increase Per Cent.
	Initial Plant	Complete Plant.	
Electric transmission	\$106,000	\$151,000	42·5
Freight on equivalent coal	32,000	159,000	400

It will be seen that with larger output the cost of freight increases at a much greater rate than the cost of electric transmission, indicating that a point would soon be reached at which electric transmission would be much cheaper than hauling coal. This is shown on Fig. 6.

However, even when an output of 75,000,000 gallons per day is reached, which represents an average load of 75 per cent of the maximum capacity of 100,000,000 gallons, the advantage in favour of electric transmission appears to be only about 5 per cent, which may be wiped out by an error in the assumptions, change in conditions, better fuel economy or reduction in rate of freight.

It would appear therefore that the large expenditure that would be involved for a first-class transmission system to convey this amount of power this distance would hardly be justified.

Of the annual cost due to transmision in this case (pages 152 and 153) 88 per cent is due to capital charges with the initial plant and 73 per cent with the complete plant.

The cost could therefore be greatly reduced by building a cheaper line, but it has been assumed that nothing less than the best possible construction and greatest security would be considered.

COST DUE TO THE PIPE LINE.

The 170 miles of gravity pipe line, providing for supply to Regina only (see Plate 38) has been estimated by the Irrigation Branch [1] to cost \$11,591,531, and this is without counting the cost of branch lines or right of way.

It has been assumed that the demand for water will be equal from the intake to the delivery at Regina, but no provision is made for branch lines to deliver the water.

The pipe passes about 14 miles south of Moosejaw.

[1] Report by Mr. F. H Peters.

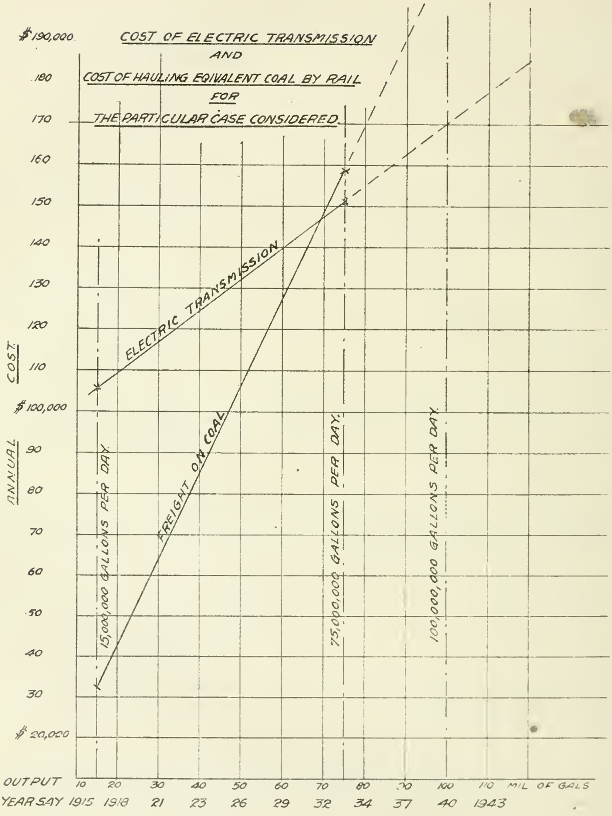
COST OF ELECTRIC TRANSMISSION
AND
COST OF HAULING EQIVALENT COAL BY RAIL
FOR
THE PARTICULAR CASE CONSIDERED.
$190,000
180
170
160
150
140
130
120
110
$100,000
90
80
70
60
50
40
30
$20,000
ANNUAL COST
ELECTRIC TRANSMISSION
FREIGHT ON COAL
15,000,000 GALLONS PER DAY.
75,000,000 GALLONS PER DAY.
100,000,000 GALLONS PER DAY.
OUTPUT 10 20 30 40 50 60 70 80 90 100 110 MIL OF GALS
YEAR SAY 1915 1918 21 23 26 29 32 34 37 40 1943

Fig. 6

If, in order to dispose of the water for which the size of pipe is designed, we allow, as a rough estimate, 25 per cent additional length (42·5 miles) for branch lines of a capacity of 50 c.f.s. at a cost of $47,899 per mile, [1] the added cost will be $2,035,708 and the total cost of the concrete pipe line only $13,627,239.

This concrete pipe line is a comparatively permanent structure, liable to repairs, but not to rapid wear or obsolescence.

The annual capital charges, however, could not well be less than the following:—

Interest, 5 per cent.

Sinking fund.—Assuming a 50-year life and a loan for the same period, the annual payment to be placed at compound interest at 3 per cent to repay the capital in that time would be 0·886 per cent, say 1 per cent.

Repairs and maintenance, say 1 per cent. Extensive damage might occur from wash-outs, frost, etc., but this 1 per cent would provide $13,630 per annum.

Taxes, etc., say 1 per cent.

Total, 8 per cent.

Eight per cent on $13,627,239 = $1,090,200.

In addition to this, there is the wrought iron pressure pipe from the pumps to the gravity pipe line intake, which is figured at $184,800. On this we may allow a thirty-year life, say a 2 per cent sinking fund, or annual charges of 9 per cent.

Nine per cent on $184,900 = $16,632.

The total annual charges would, therefore, be:—

On the concrete pipe.	$1,090,200
On the pressure pipe.	16,630
	$1,106,830

or $3,032 per day.

As shown under the head of 'Quantity of water required,' it is probable that the average daily consumption will not exceed 15,000,000 gallons per day at the start, and this may not reach the full quantité of 100,000,000 gallons per day for 25 years or more.

The cost per 1,000 gallons due to the pipe line only would therefore be:—

Gallons per day.	Cents per 1,000 Gallons.
15,000,000	20·20
20,000,000	15·18
50,000,000	6·06
75,000,000	4·02
100,000,000	3·03

which will be a heavy burden on the undertaking in its early stages.

Figure 7 shows the relation of cost per 1,000 gallons to quantity of water delivered.

Total Cost of Water Delivered to Consumers.

Pumping at South Saskatchewan river and gravity delivery. Main pumping cost based on steam turbines and centrifugal pumps as an average figure—see summary on pages 128 and 129.

Initial installation: Capacity, 20,000,000 gallons per day. Output, 15,000,000 gallons.

[1] Report by Mr. F. H. Peters.

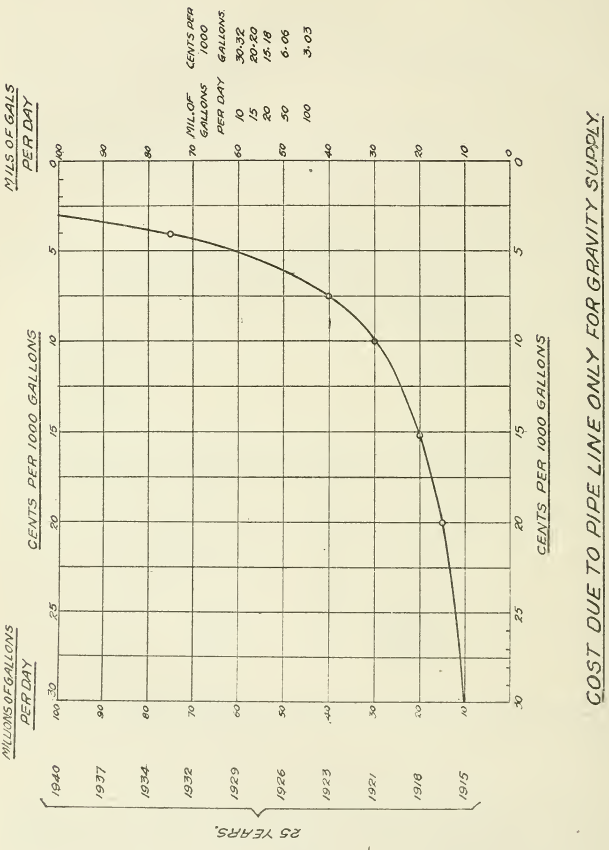
COST DUE TO PIPE LINE ONLY FOR GRAVITY SUPPLY.
MILS OF GALS PER DAY
CENTS PER 1000 GALLONS
MILLIONS OF GALLONS PER DAY
MIL. OF GALLONS PER DAY
CENTS PER 1000 GALLONS.
10 30.32
15 20.20
20 15.18
50 6.06
100 3.03
1940
1937
1934
1932
1929
1926
1923
1921
1918
1915
25 YEARS.

Fig. 7.

Complete installation: Capacity, 100,000,000 gallons per day. Output, 75,000,000 gallons.

	Cost in cents per 1,000 gallons due to:— Pumping to height of land.	Main Pipe Line.	Mechanical Filtration	Local pumping and distribution.	Total cost of delivering to consumers.	Per cent of total cost due to main pumping plant at the river.
Initial installation	2·26	20·20	1·5	15·0	39 cents.	5·8
Complete installation	1·66	4·02	1·3	12·0	19 cents.	8·75
Average....	1·96	12·11	1·4	13·5	29 cents.	6·75%

CONCLUSIONS.

The preceding table shows at a glance the relative importance of the different items entering into the total cost of water delivered to the consumer.

It will be seen that the cost of pumping at the river is but 6 to 9 per cent of the total cost and consequently a considerable difference in the cost of power makes little difference in the total cost; for instance, 25 per cent difference in the cost of the power is less than 2 per cent on the total cost.

The important items are:—

(1) Cost due to the pipe line.

(2) Cost due to local pumping and distribution.

The figure taken for the last item would be high for a well-managed undertaking in a large town, but it is intended to represent the average result of a number of towns large and small.

Assuming, as the present knowledge appears to indicate, that the South Saskatchewan river is the only satisfactory source of water for the district, and that the cities interested must have a larger supply of water than they can obtain locally, then the real problems are:—

(1.) Can the cost of the pipe line be substantially reduced?

(2.) Can the cost of local pumping and distribution be reduced?

It may be possible, and it is at all events worth investigation, whether the substitution of a pressure instead of a gravity system would not achieve both these results.

A pressure system, if practicable, would permit of a much shorter pipe line and one embracing a much larger number of towns, thus probably diminishing the cost and distributing it over a larger number of towns.

Also, if the water can be delivered at a pressure of say 65 pounds to the various cities, the local pumping plants could be dispensed with, and the saving thereby should much more than compensate for the increased expenditure at the main pumping station at the river.

These questions are further considered in the following Appendix.

INDEX TO MAP SHOWING SOURCES OF FUEL POWER AND INDICATIONS THEREOF (Plate 39).

Based on Map No. 97 by D. B. Dowling, B.A.Sc., in the 'Coals of Canada,' No. 83, 1911, issued by the Department of Mines, Ottawa.

1. Salvador. Seam disclosed here. [1]
2. Kerrobert. Seam disclosed here. [1]

[1] D. B. Dowling, Jan. 27, 1913.

3. Eagle lake. The seam here is believed to be the same as that stated to be at Eagle hills in No. 5 below. (1)

4. Brock. Large quantities of lignite are found here. (2)

5. Eagle hills. Coal seams have been found here. (2)

6. Outlook. Coal deposits here. (1)

7. Saskatchewan Landing. A 4-foot seam disclosed at range 16, township 20, section 14. (1)

8. Maple creek. Seams of bituminous coal, underlie the adjacent country. Flow of natural gas reached at 1,200 feet (2); 4-foot seam at depth of 196 feet; 7-foot seam at 292 feet. (1)

9. Swift Current. Coal mine being opened. Company formed to bore for natural gas. (2)

10. Cypress hills. Coal is being mined here. (3)

11. Moosejaw. A well was sunk 1,200 feet at the city electric power house and indications of natural gas obtained.

12. Pense. A flow of natural gas was struck here, but not of much importance. (4)

13. Rouleau. Large quantities of lignite are found here. (2)

14. New Warren. 3-foot 4-inch seam at range 24, township 12, section 24. (1)

15. Dirt hills. Seams of coal are known to exist here. (5)

16. Lake of the Rivers. Consumer's Coal Company. See under latter heading in body of report.

17. Wood Mountain district. Lignite closely resembles that of Estevan district. Seams from 3 to 17 feet. Not developed. (6)

18. Manitoba and Saskatchewan Coal Company. Ultimate capacity, 2,000 tons per day. (6)

19. Eureka Brick and Coal Company. Capacity, 200 tons per day. (6)

20. Western Dominion Collieries. Equipment for 1,000 tons in 10 hours. (6)

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[1] D. B. Dowling, January 27, 1913.

[2] Pamphlets by Minister of Agriculture, Saskatchewan, 'Saskatchewan, Canada,' 1910 and 1911.

[3] C. P. R. Co. pamphlet, 'Western Canada,' 1912.

[4] Mr. T. Martin, div. engineer, C.P.R., Moosejaw.

[5] Memoir 24E, Department of Mines, Ottawa, 1912.

[6] 'Coals of Canada,' Vol. 1, 1912. Department of Mines, Ottawa.

APPENDIX.

PROPOSED PRESSURE SYSTEM OF DELIVERY.

As the primary object of the foregoing report has been to deal with the sources and cost of power, it may be considered that a suggestion to use a pressure instead of a gravity system of supply is not within its scope.

The cost of power, however, is only of consequence as affecting the total cost of the water delivered, and an investigation at once makes it apparent that the greatest item in such cost for many years to come will not be that of power but that of the pipe line (see page 175).

If it can be shown that an increased cost for power by an alternative method of delivering the water will probably decrease the total cost of water delivered, then it is considered that the discussion of such method is in order, but not the preparation of estimates, which will be a large subject in itself.

It will have been seen from the report that all the proposals so far made have been based on 'gravity supply,' meaning in this case pumping from the river to an intake on the height of land, and allowing the water to flow from thence to the cities by a concrete pipe line which will deliver it with little or no pressure at the level of the Canadian Pacific railway rails in each city, this pipe line to be constructed initially of full capacity at a cost of 12 to 14 million dollars (see page 172).

This gravity pipe line necessitates passing through a country more or less remote from all towns except Regina (se Plate 38), and it is by no means clear that the intermediate towns could be supplied even by long and expensive branch lines; in fact, in some cases it appears from the respective elevations (see table page 104) that they could not.

The basic idea appears to be to provide an undertaking of general public benefit in the sense of making the supply available not only to two or three of the larger cities, but also to the large number of intermediate smaller towns. The methods and routes so far proposed do not appear to make this possible, or even to take it into consideration.

If the pipe line is to be wholly or partly unproductive of revenue throughout its length, the cost will be heavy on the cities at its termination; if, on the other hand, a method can be used which permits of supply to intermediate towns without appreciable length of branch lines, the cost to all users should be diminished and the benefit will be much more general.

The first section of the proposed gravity concrete pipe is 10 feet 6 inches internal diameter and is buried 6 feet clear, necessitating a trench about 17 feet deep and 12 feet 6 inches wide, and from the nature of the work it would probably not pay to lay this as two pipes of smaller diameter at different times, although the full capacity may not be required for say 25 years or more.

On the other hand, with a pressure system a much smaller diameter steel or wood-stave pipe might be laid at probably much less cost, sufficient for 10 or 15 years ahead, such pipe following the route of the railroad and centres of population. Later on, when conditions warrant it, a second parallel pipe could be laid, or feeder pipes could be laid to points of heavy demand.

GRAVITY SYSTEM.

Summing up the above, the gravity pipe system appears to entail the following disadvantages:

(1) The pipe line is remote from intermediate towns, and its length is about 40 per cent more than the distance by railroad. It is also far from being easily accessible for inspection and repairs.

(2) The annual capital charges during the early stages will be an excessive burden.

(3.) The water will be delivered without pressure and each town must maintain its own pumping station to add the necessary pressure for distribution.

(4.) To get the necessary height of land will necessitate placing the pumping station about 24 miles from the railroad.

PRESSURE SYSTEM.

To avoid these disadvantages it is suggested that a pressure instead of a gravity system should be considered.

The addition of about 65 pounds pressure at the main pumping station would probably give all the pressure necessary for domestic supply.

A pressure system would enable the pipe to be laid by the shortest or most desirable route independently of the contour of the land.

The pressure system would offer the following advantages:—

1. The plant can be located at the most advantageous spot independent of the elevation of the adjacent height of land. It might be located at 'the Elbow,' within one or two miles of the railroad instead of about 20 miles distant. This offers great advantages for the delivery of machinery and supplies, and for access to the works when completed. It would also avoid the expenditure of about $400,000 and an annual cost of about $48,000 for a branch railway line (see pages 106 and 107).

2. The pipe can be laid near the route of the railway, diminishing its length by about 40 per cent. avoiding the cost of branch lines, and making it far more accessible for repairs.

3. It will probably pay to lay a much smaller steel or wood stave pipe, sufficient for fifteen years ahead, diminishing the initial burden on the undertaking (see also above).

4. It can then supply intermediate towns between the principal cities without branch lines, thus distributing the costs, increasing the benefits, and producing revenue along its whole length. There are fourteen towns on the Canadian Pacific Railway line between Elbow and Regina and others coming into existence on the routes of other railroads closely adjacent.

5. The necessity for an individual pumping plant in each city or town will be done away with, except for fire or reserve purposes.

Any inequality of pressure due to direct pumping and varying demand could probably be met by the addition of standpipes, etc., at suitable points, but it is possible that in the case of simultaneous supply to a number of cities and towns, the resultant demand would be so steady that but little would be needed in this direction.

Or, each city could provide its own elevated tank or reservoir giving such storage and pressure as its engineer considered necessary, the supply to such tank being delivered from the main pumping station to the top of the tank. Any inequalities of pressure due to direct pumping could not then affect supply consumers.

The elevations of the cities and towns on the proposed route are such that the pressure at all points would be nearly uniform (page 104).

A system of direct pumping under pressure, properly designed, would not appear to greatly affect the safety of supply, since in any case the supply must depend upon direct pumping from the river to the height of land, and the additional pressure would be taken care of by steel or wood stave pipes instead of by concrete pipes for a gravity supply.

To provide for fire pressure, if higher pressure was considered necessary in the cities and larger towns, each city could provide its own steam fire engine or simple and inexpensive motor driven pumps to act as boosters, such methods costing but a frac-

tion of the capital and operating costs necessary to maintain a separate plant in constant operation for providing the pressure necessary for domestic purposes in each city.

While increased pressure means greater first cost for plant and greater cost of pumping, it does not mean that these would be increased proportionately.

If, therefor, the development is to be carried out on a co-operative basis amongst the municipalities, it is probable that adding the necessary pressure at the river would considerably diminish the total cost of the water delivered to the consumer, by reducing the cost of the pipe line and reducing the cost of local pumping.

SIMILAR WATER SUPPLY SYSTEMS.

A few notes on what has been or is being done on systems similar to that herein contemplated may be of interest to those reading this report.

New York city has nearly completed an aqueduct largely consisting of pressure tunnels, from a point 90 miles distant in the Catskill mountains, which will have an ultimate capacity of 600 million gallons daily.

Los Angeles, California, has nearly completed an aqueduct 222 miles long, with a capacity of 273 million gallons per day.

San Francisco, California, has drawn plans for obtaining its supply from a distance of 180 miles at an elevation of 3,800 feet. The total cost of the scheme, giving a supply of 240 million gallons daily is estimated at $37,000,000.

Manchester, England, obtains its supply from lake Thirlmere through an aqueduct nearly 100 miles long.

Birmingham, England, obtains its supply from the Elan river, in Central Wales, through a 70-mile aqueduct.

Glasgow, Scotland, is supplied through a 30-mile aqueduct from Loch Katrine.

Winnipeg, Manitoba.—The city is carrying on surveys for a gravity supply from Shoal lake, a portion of the lake of the Woods. The distance is about 90 miles and the tentative plans contemplate the supply of 25,000,000 gallons per day. Steps are being taken to include the surrounding towns and cities in a 'greater Winnipeg water district.' Estimated cost, $16,000,000.

Mexico.—An interesting description of a water supply pipe line of similar length but smaller diameter is given by J. L. Campbell, M. Am. Soc. C.E., in a paper on 'the Water Supply of El Paso and Southwestern Railway, New Mexico.' (1)

This system is a combination of gravity and pressure supply and supplies all the requirements of the railway for a distance of 128 miles.

The system includes 116 miles of wood stave pipe and 19 miles of cast-iron pipe, total 135 miles, along an approximately straight route; also, one 422,000,000 gallon storage reservoir, four 2,500,000 gallon service reservoirs, two pumping plants in duplicate, stand-pipes, &c.

The pipe line is carried over a very broken and irregular country.

From a small concrete dam across the creek at an elevation of 7,728 feet the pipe line drops down 5½ miles to 6,980 feet (difference, 235 feet), continuing 5 miles to the storage reservoir. From thence it drops to Coyote at 5,810 feet. This first section brings the water from the source to the railway and is 32 miles long.

The second or pumping section of 36½ miles, extends east along the railway, rising from 5,810 feet at Coyote to 6,750 feet (940 feet) on Corona Summit where it delivers to a reservoir.

The third section, which is a gravity system, extends from the reservoir on Corona Summit, dropping from 6,750 to 4,570 (2,180 feet) in 80 miles.

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(1) Trans. Am. Soc. C. E., vol. LXX, Dec., 1910, p. 164.

The pressure is limited to 130 pounds per square inch (300 feet head) except on 19 miles of the pump main, where the estimated maximum pressure is 310 pounds (716 feet head).

The maximum diameter of the pipe is 16 inches, and this section delivers about 3,120,000 Imperial gallons per day.

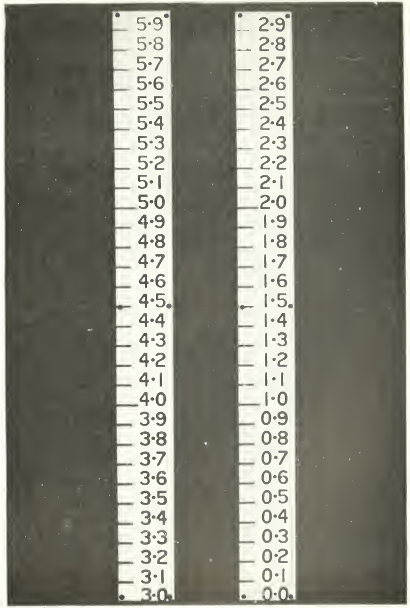
There are regulating, relief check, blow-off and air valves, air chambers and open stand-pipes, designed to keep the wood pipe full, regulate flow, prevent accumulation of pressure and water hammer, and remove sediment.

All of which is respectfully submitted.

H. E. M. KENSIT.

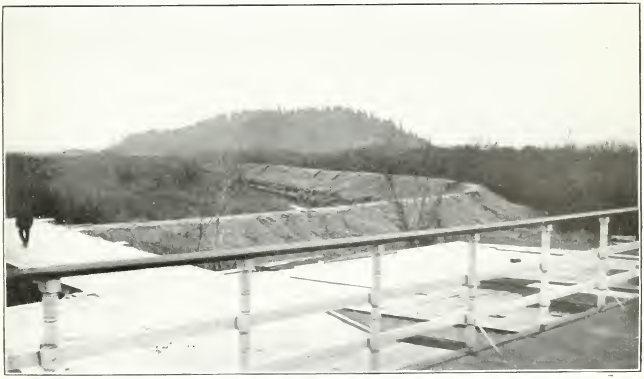
25—1914—viii—13

B. C. Railway Belt Hydrographic Survey. Gauging Station on Guichon Creek.



B. C. Railway Belt & Manitoba Hydrographic Surveys Enamelled gauges.

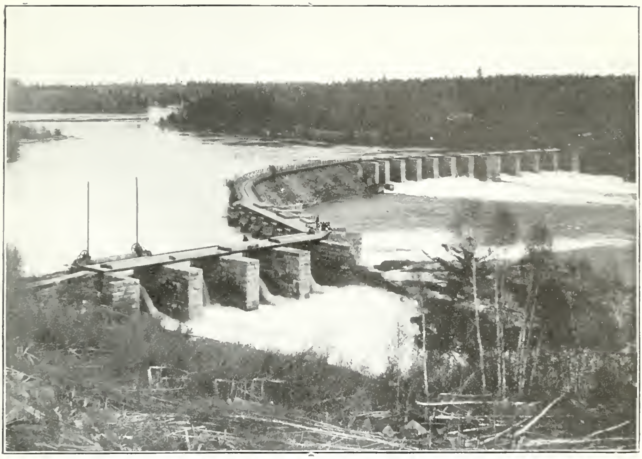
B. C. Railway Belt Hydrographic Survey. Making wading measurement on Monte Creek.



B. C. Railway Belt Hydrographic Survey. Pitt Meadows. Rannie's Reclamation Project. Wharf and Angle of Dyke.

B. C. Railway Belt Hydrographic Survey. Pitt. Meadows. H. Bauthier's Reclamation Project Sturgeon Slough.

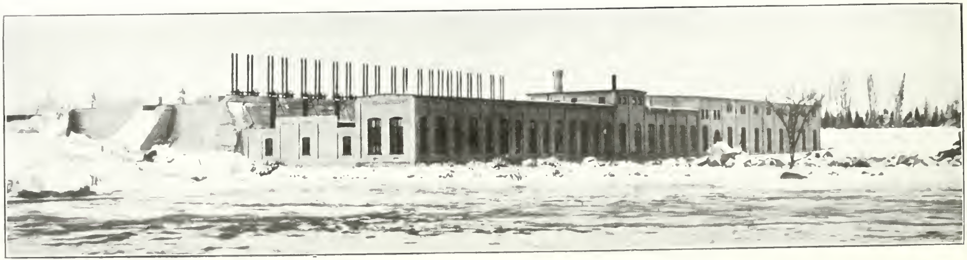
B. C. Railway Belt Hydrographic Survey. Pitt Meadows. H. Bauthier's Reclamation Project Ditch & Dyke.



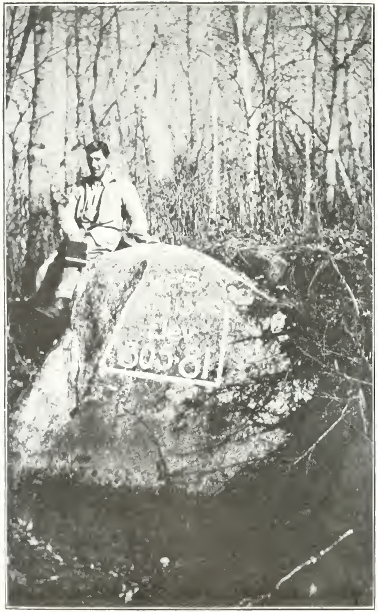
Winnipeg River. Norman Dam Controlling Outlet Lake of the Woods.

Winnipeg River. Pointe du Bois Falls. Showing Dam of City of Winnipeg Power Plant in distance.

Winnipeg River. Panoramic View City of Winnipeg Development at Pointe du Bois Falls.



Winnipeg River. Winnipeg Electric Railway Power House. Pinawa Channel.



Winnipeg River Power Survey. Rock Bench mark.

Winnipeg River. City of Winnipeg Development. Generator Room.

Winnipeg River. Winnipeg Electric Railway. Interior Generator Room. Pinawa Channel.

Winnipeg River. Second McArthur Falls.

Winnipeg River. Third pitch. Grand du Bonnet Falls.

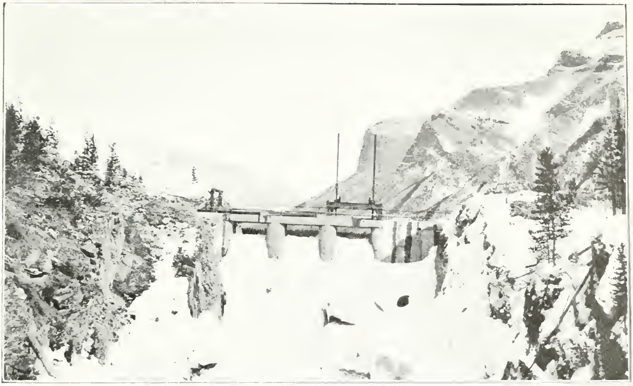
Winnipeg River. Silver Falls.

Manitoba Hydrographic Survey. Brandon Gauge

Bow River Basin. Power survey bench-mark.

Manitoba Hydrographic Survey. Cable Station for metering. Slave Falls Winnipeg River.

Manitoba Hydrographic Survey. Boat Station for metering. Pinawa Channel Winnipeg River.

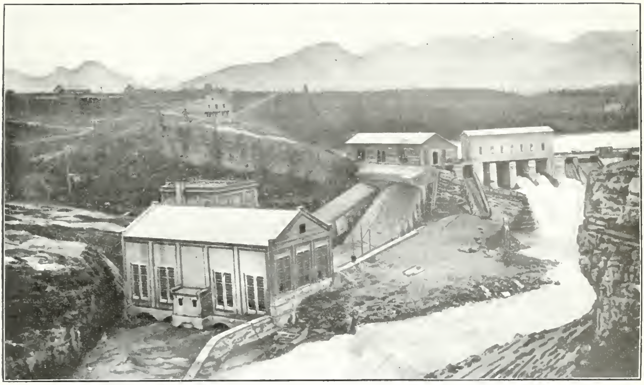


Lake Minnewanka Storage. Calgary Power Company's Dam under Ice conditions.

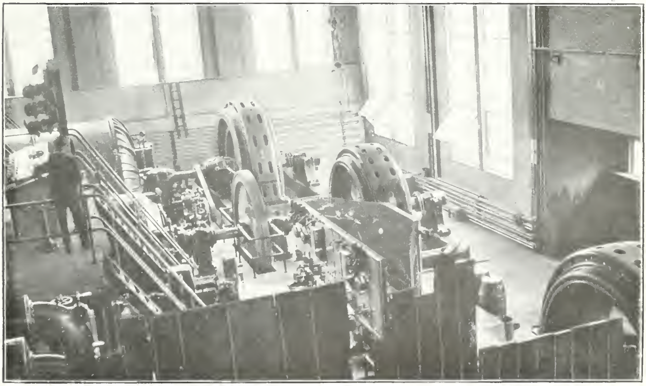
Bow River Basin. Ghost River shewing nature of river bed.

Lake Louise Power Development. View of Lake.

Lake Louise Power Development. Upstream face of Bridge.



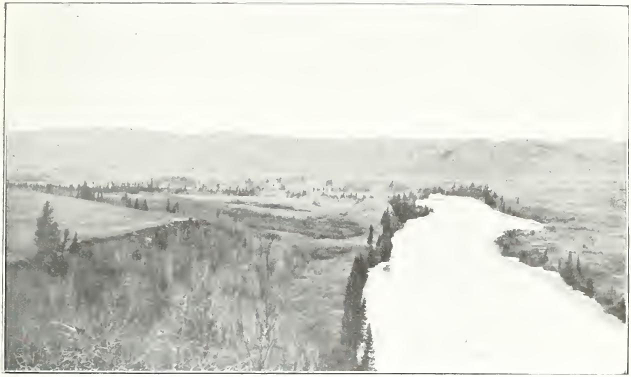
Bow River. Horseshoe Falls. Calgary Power Company's Development.



Bow River. Horseshoe Falls. Interior Calgary Power Company's Plant.

Bow River Basin. Kananaskis Falls.

Bow River. Bow Fort Damsite.

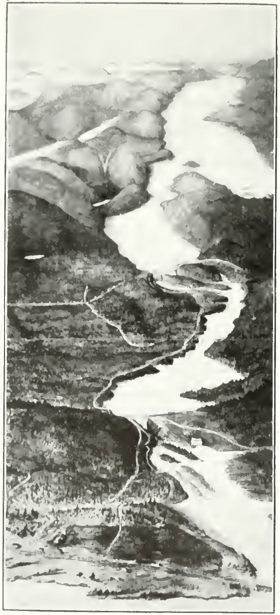


Bow River. Mission Damsite.

Bow River. Radnor Damsite.

Athabaska River. Grand Rapids from below.

Vancouver Power Company. Coquitlam Dam B. C. Control Tower. New Westminster Water supply Intake.



Western Canada Power Company. Birds-eye View of Stave River & Lake Showing both Power Sites.

Coquihalla River B. C. Proposed Power Site.

Vancouver Power Company. Power House on Burrard Inlet.

Vancouver Power Company. Coquitlam Dam B. C. Old Dam.

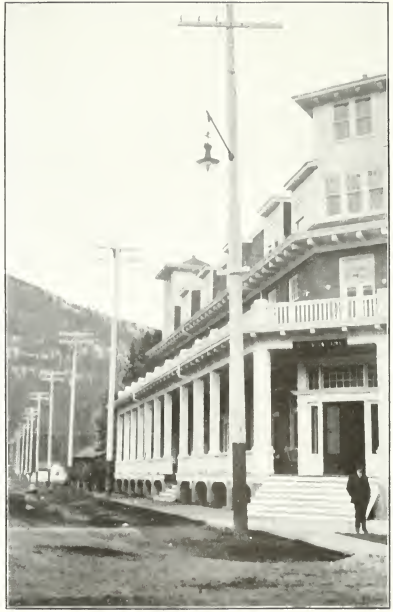
Vancouver Power Company. Coquitlam Dam B. C. Panoramic View of Dam under Construction.

Vancouver Power Company. Coquitlam Dam B. C. Hydraulicing.

Western Canada Power Company. Stave Falls Power House.

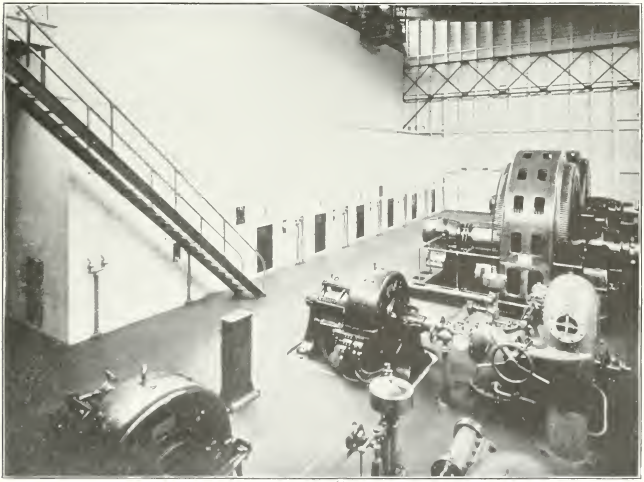
Cascade River Power Development. Main Street, Banff. Looking South.

Western Canada Power Company. Transmission Line Tower.



Cascade River Power Development. Typical Distribution Pole System Banff.

Western Canada Power Company. Stave Falls. Interior of Power House.



Western Canada Power Company. Stave Falls. Interior of Power House.

Cascade River Power Development. Minnewanka Dam. Looking downstream. Intake on left.

Cascade River Power Development. Minnewanka Dam. Looking upstream. Penstock connection on right.

Cascade River Power Development. Cascade River Canyon. Looking down stream from bridge.

Cascade River Power Development. Pipe Line Route. Looking downstream.

Cascade River Power Development. Power Station. Looking upstream. River Shutoff.

Cascade River Power Development. Power Station Site. Looking upstream. River Normal.

Pasquia Reclamation Project. Pasquia River. 11 miles below the Pas Forks.

Pasquia Reclamation Project. Pasquia River. 4 miles below the Pas Forks.

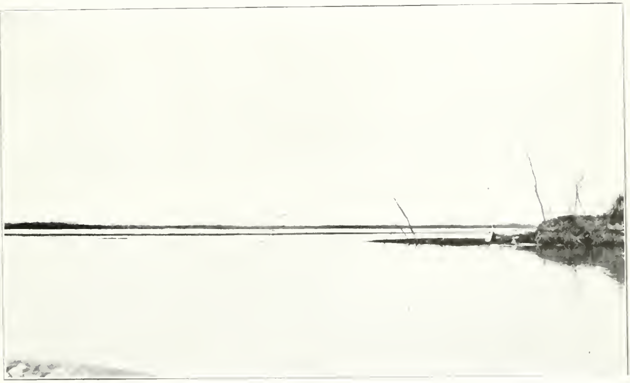
Pasquia Reclamation Project. Pasquia River. Grass land near Forks.

Pasquia Reclamation Project. Saskatchewan River. Showing Poplar shore line.

Pasqnia Reclamation Project. Saskatchewan River Showing Willow shore line—flooded area in background.

Pasquia Reclamation Project. Saskatchewan River. Looking up from mouth of Little river.

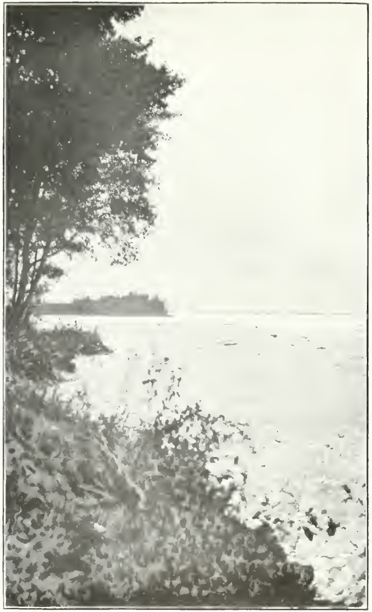
Pasquia Reclamation Project. Demi Charge Rapids & Cross Lake. Cross Lake Camp.



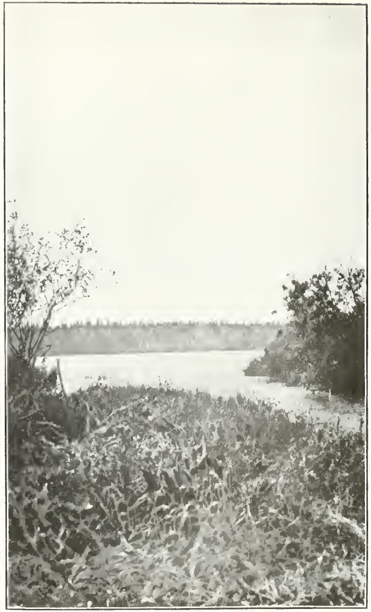
Pasquia Reclamation Project. Saskatchewan River. Lake expansion to north. 23 miles below The Pas.

Pasquia Reclamation Project. Looking up the Demi Charge from Cross Lake Camp.

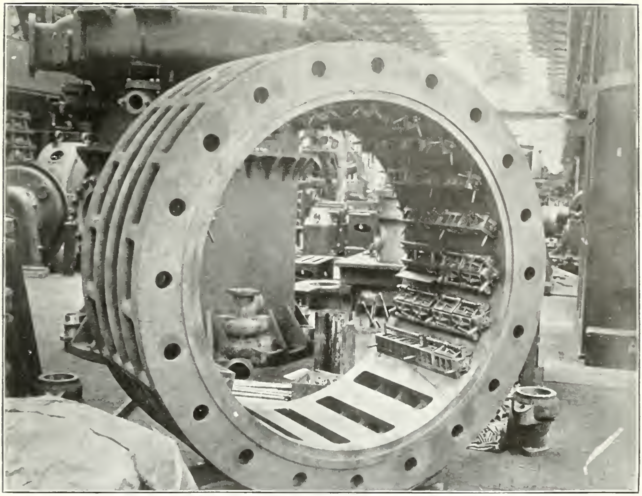
Pasquia Reclamation Project. Cross Lake and Calico Is. from Cross Lake Camp.



Pasquia Reclamation Project. Looking down Demi-Charge Rapids.

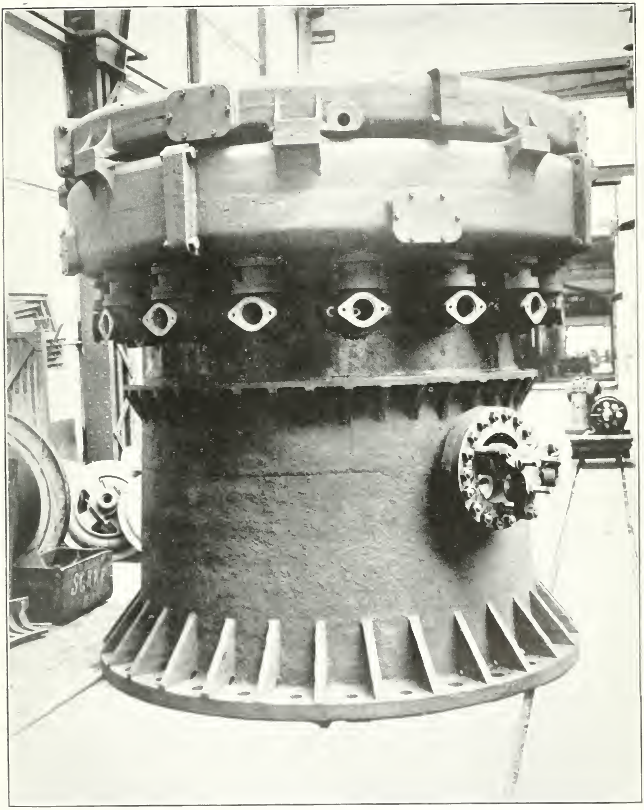


Pasquia Reclamation Project. Looking across head of Demi-Charge Rapids.

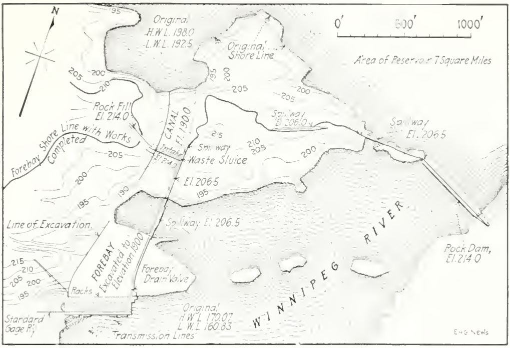


The Humphrey Internal Combustion Pump. Suction Valve Box of unit now erected at Chingford, England.

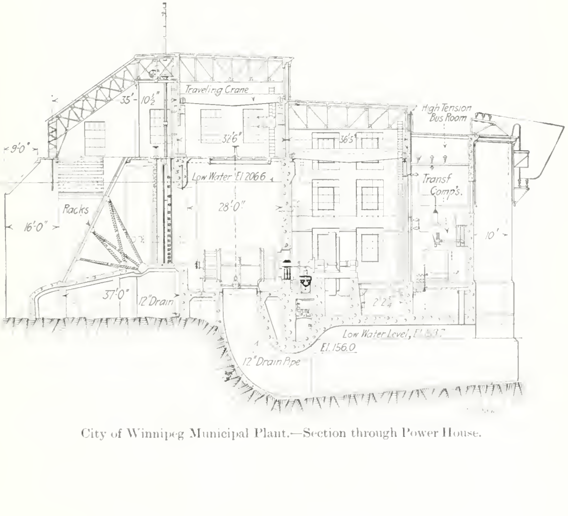
The Humphrey Internal Combustion Pump. Chingford Reservoir England showing discharge from one 40,000,000 gal. pump.



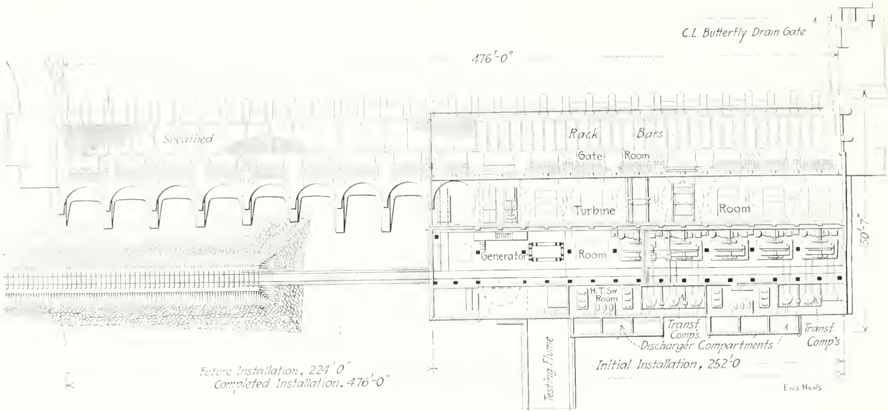
The Humphrey Internal Combustion Pump. Combustion Chamber 40,000,000 Gal. Pump, partly fitted.



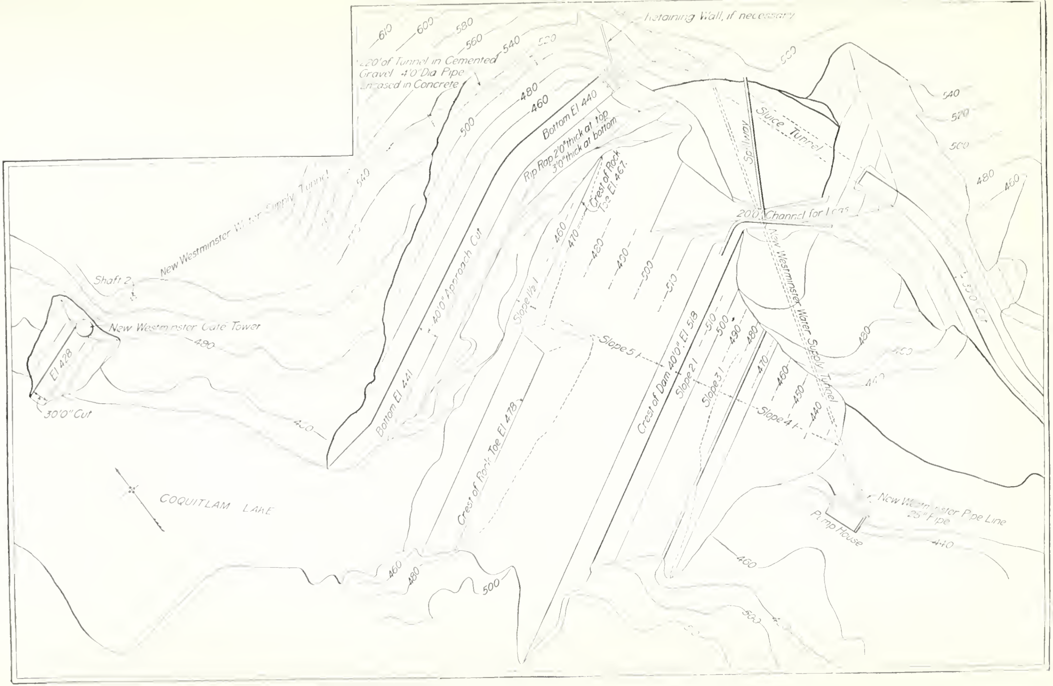
City of Winnipeg Municipal Plant,—General Layout.



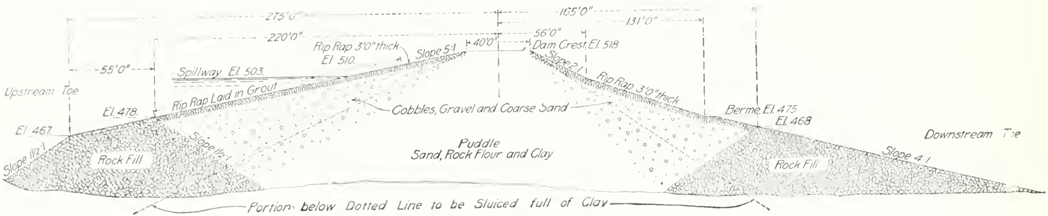
City of Winnipeg Municipal Plant.—Section through Power House.



City of Winnipeg Municipal Plant, Sectional plan of Power House.



Vancouver Power Co. Coquitlam Dam, Layout of Dam.



Vancouver Power Co, Coquitlam Dam,—Cross section through Dam.

DEPARTMENT OF THE INTERIOR

ANNUAL REPORT

OF THE

TOPOGRAPHICAL SURVEYS BRANCH

1912-13

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OF THE

SURVEYOR GENERAL OF DOMINION LANDS

1912-13

Department of the Interior,
Topographical Surveys Branch,
Ottawa, August 2, 1913.

The Deputy Minister of the Interior,
Ottawa.

Sir,—I have the honour to submit the following report of the Topographical Surveys Branch for the year ended March 31, 1913.

The surveys in northern Manitoba and the Peace River district were on a larger scale than before. Eighty-two parties were employed, eighty-one of whom were engaged for the whole season, and one for a short period only. The number of parties under daily pay was forty-four, of whom five were for the inspection of contract surveys, ten for the survey of base lines and initial meridians, one for levelling, one for latitude observations, one for triangulation, and the remaining twenty-six for subdivision, resurvey and miscellaneous work of various kinds. Thirty-seven parties were employed under contract on township subdivision.

The following table shows the distribution of parties by provinces:—

Parties.	In Man.	In Sask.	In Alta.	In B.C.	Partly in one Province and partly in another.	Total.
Paid by the day	4	6	16	8	10	44
Under contract	10	18	9	....	....	37
Parties engaged for a short time only	....	....	1	....	....	1
Totals	14	24	26	8	10	82

One hundred and fifty-two whole townships and ten fractional townships were completely subdivided and a partial subdivision was made in four hundred and seventy-five others. Twenty-two whole and two fractional townships were also completely resurveyed and in two hundred and two others portions of the township were resurveyed.

The following statement shows the average number of miles of survey for each party during the last four years:

1909	412 miles.
1910	279 "
1911	280 "
1912	266 "

SURVEY OF BLOCK OUTLINES.

Ten surveyors were employed in establishing initial meridians and base lines, and another surveyor retraced the principal meridian. Five of these were located in Alberta, two in Saskatchewan, and three in Manitoba.

Mr. G. H. Herriot, D.L.S., produced the principal meridian north from the sixteenth to the eighteenth base line. This line crosses many bodies of water necessitating much triangulation. In six miles nine channels of Nelson river were crossed. During the summer supplies had to be transported by canoes or man packing, the boggy nature of the district preventing the use of horses.

Parts of the fifteenth, sixteenth and seventeenth base lines west of the principal meridian were run by Mr. O. Rolfson, D.L.S. His report has not yet been received as the field work will not be completed till the end of the present season.

The district through which Mr. E. W. Robinson, D.L.S., produced the second meridian being very wet, the line had to be surveyed in winter. Mr. Robinson has ceased operations, but has not had time yet to prepare his general report.

Mr. T. H. Plunkett, D.L.S., ran portions of the tenth, eleventh, twelfth, thirteenth and fourteenth base lines west of the principal meridian and part of the thirteenth west of the second meridian. The district crossed by these lines is low and very wet. Floating bogs are numerous and water channels scarce, the mossy surface hindering drainage. The slope of the country will, however, be sufficient for drainage when drainage channels are opened.

A portion of the third meridian, from the seventeenth to the eighteenth base line, was established by Mr. A. Saint Cyr, D.L.S. He also surveyed the eighteenth base line from the third to the fourth meridian. The country along the third meridian is so marshy that the roads had to be corduroyed or brushed to bear the weight of the loaded pack ponies. A great part of this boggy land is due to beaver dams which interfere with the natural flow of water. Along the eighteenth base line the land is higher. Stony patches are frequent, and watercourses and lakes are numerous. The surface is mostly wooded, but the timber is not of large size.

The most important industry of the district is fishing which is extensively carried on, the many large bodies of fresh water furnishing enormous quantities of fish from which the companies engaged in this trade obtain a large revenue.

The fourth meridian was produced northerly by Mr. J. B. McFarlane, D.L.S., from the northeast corner of township 105 to lake Athabaska. The country along this portion of the meridian is rolling, with sand hills and small lakes, but north of the twenty-eighth base line muskegs are numerous.

Mr. McFarlane also ran a portion of the twenty-fourth base line west of the fourth meridian.

Mr. Geo. McMillan, D.L.S., surveyed the twentieth base line across ranges 10 to 26 west of the fourth meridian. Good hay and water were found to be abundant. The district is well suited for ranching and access is easy, Athabaska river flowing directly north through it. The surface is densely wooded in Pelican mountains west of the Athabaska, but the timber is too small for milling.

Along the Athabaska there is a strip of dry land, but beyond this rim a muskeg, which had to be corduroyed to carry the pack ponies, extends westerly to the Pelican mountains. Beyond the muskeg, the ground is firm and the surface rolling and hilly.

The nineteenth base from range 5 west of the fourth meridian to the fifth meridian was surveyed by Mr. G. H. Blanchet, D.L.S. The country is similar to that along the base line immediately north which was surveyed by Mr. McMillan, except that the land east of the Athabaska has less muskeg.

Mr. A. H. Hawkins, D.L.S., ran the twenty-third base line from the fifth to the sixth meridian. Access to this work was obtained by sleighs as no summer roads are opened and no water routes are available. Supplies had to be brought in from Edmonton for the eastern portion of the work but for the western part supplies were taken down Peace river.

Forest fires raged during the survey of this line and the party had some narrow escapes.

Much time was lost on this line going around muskegs which could not be crossed, and progress was also retarded by extensive windfalls, the whole district having been overrun by fire.

The twentieth base line across ranges 18 to 26 and the twenty-third base line across ranges 1 to 8, west of the sixth meridian were run by Mr. J. R. Akins, D.L.S. He also resurveyed a portion of the sixth meridian. The twentieth base line crosses very rough and hilly country, and consequently the work proceeded slowly. This rendered levelling especially difficult, and although many long sights were taken across the deep valleys, trigonometric methods had to be used in many cases.

Along the twenty-third base line the whole country for one hundred miles north of Dunvegan was burnt over, lack of rain in the fall of 1912 being the cause. These forest fires, which in one case had to be fought for three days to save the horses and outfit, destroyed all the grass. The pack train had to travel fourteen miles from camp to secure horse feed when working along the sixth meridian, and when fifteeen miles of this line had been run, the work had to be abandoned as no feed was available.

These fires are a source of great danger to survey parties as caches of supplies are frequently destroyed, and unless additional supplies can be readily secured the work has to be abandoned.

INSPECTION OF CONTRACT SURVEYS.

A chief inspector and five inspectors were employed on the examination of surveys made under contract. The chief inspector was Mr. E. W. Hubbell, D.L.S., and the inspectors, Messrs. P. R. A. Bélanger, D.L.S., C. F. Miles, D.L.S., L. E. Fontaine, D.L.S., G. J. Lonergan, D.L.S., and W. J. Deans, D.L.S.

The work of the inspectors is now more difficult than when the contract surveys were located on prairie or level wooded land. Contracts at present comprise heavily wooded land intersected with marshes which render inspection slower. Access to the work is also a great obstacle and supplies have to be forwarded over roads which are sometimes in bad condition.

Accordingly the inspectors perform very little miscellaneous work and travelling parties consisting of a surveyor and an assistant, with the aid of local labour, have to be employed for such work.

This condition of affairs is likely to continue if surveys are to be kept ahead of settlement and railway construction.

Messrs. Bélanger and Deans inspected the contracts in Manitoba and eastern Saskatchewan, while Messrs. Fontaine, Lonergan and Miles examined the work in Alberta and western Saskatchewan.

BRITISH COLUMBIA SURVEYS.

Six surveyors were employed on work in the railway belt of British Columbia.

Mr. J. A. Calder, D.L.S., surveyed lands in the Thomson and Nicola valleys in the vicinity of Spence's Bridge, and also near Walhachin. The portions surveyed are well adapted for fruit raising, though irrigation is necessary to secure good results.

Mr. A. Lighthall, D.L.S., retraced the townsite of Langley, ran traverses and took levels at Woodhaven, and performed several miscellaneous subdivision surveys. He also surveyed the outlines of timber berths along the North Arm of Burrard Inlet, and Pitt lake.

Some subdivisions around Kamloops was done by Mr. C. H. Taggart, D.L.S. He also established a portion of the outline of the railway belt west of Adams lake. This outline is very rough and thickly wooded, the ground in places being covered with heavy windfall.

Mr. N. C. Stewart, D.L.S., carried on subdivision in the vicinity of Enderby, Golden and Moberly, and surveyed the townsite of Rogers Pass in township 27, range 25 west of the fifth meridian.

Subdivision surveys were made by Mr. P. Melhuish, D.L.S., in the vicinity of Keefers and Spuzzum. He also surveyed a timber berth at the latter place.

Mr. A. V. Chase, D.L.S., continued the examination of vacant lands in the Kamloops district.

TOWNSHIP SUBDIVISION SURVEYS.

Most of the subdivision surveys were performed under contract, but in some cases the surveys were made by daily paid surveyors, as the work was of such a nature that it could not be done at contract rates.

Mr. E. W. Berry, D.L.S., subdivided lands along the Hudson Bay railway near Le Pas, which were wanted for settlement.

Mr. P. B. Street, D.L.S., surveyed in the foot-hills in southeastern Alberta and Mr. E. S. Martindale, D.L.S., worked farther north in the foot-hills, about fifty miles southwest of Calgary.

Subdivision near the Yellowhead Pass was done by Mr. C. A. Grassie, D.L.S. The land subdivided lies along the line of the Canadian Northern railway within the Jasper Forest Park reserve.

In the Brazeau district, Mr. A. L. McNaughton, D.L.S., subdivided lands on which coal claims had been staked out.

Mr. L. Brenot, D.L.S., subdivided land on the upper Peace river in the vicinity of Hudson Hope and Fort St. John settlements.

The most isolated surveys were those of Mr. J. S. Galletly, D.L.S., in the Vermilion district, over 150 miles north of Peace River Crossing. Some first-class farming land in the valley of Peace river was subdivided and settlers who had been in the district for some time had the boundaries of their homesteads properly defined.

CORRECTION, RESTORATION AND MISCELLANEOUS SURVEYS.

Mr. A. G. Stuart, D.L.S., retraced about one hundred and seventy miles of the principal meridian north from the international boundary. This work was necessary to locate an error of 26·49 chains in township 35. It was found that the discrepancy was due to the use of incorrect chains by the surveyors who ran the line in 1871. Mr. Stuart did some traverse and correction surveys in Manitoba, and retracement and resurvey work was carried on in the same province by Mr. C. F. Aylsworth, D.L.S.

In Saskatchewan, Messrs. C. Rinfret, D.L.S., and S. L. Evans, D.L.S., worked on miscellaneous resurveys, retracement and restoration surveys, and the same class of work was attended to in Alberta by Messrs. J. A. Calder, D.L.S., and G. A. Cowper, D.L.S.

Four travelling parties were employed to carry on miscellaneous small surveys, and investigate errors, drying up of lakes, lost monuments, etc. Local assistance was procured when necessary, and as the work for the most part was in settled or partly settled districts no camp equipment was necessary. Messrs. G. A. Bennett, D.L.S., R. C. Purser, D.L.S., F. V. Seibert, D.L.S., and B. H. Segre, D.L.S., were the surveyors in charge of the travelling parties.

Mr. M. P. Bridgland, D.L.S., continued the triangulation work in the railway belt of British Columbia.

A base line about five miles long was measured at Salmon Arm with the invar wire base apparatus. Great precision was required in the measurement, the location of all triangulation stations in the vicinity being determined from this base. Mr. Bridgland also surveyed some villa lots at Banff.

The topographical survey in the Fiddle Creek district in the Jasper Forest Park Reserve was continued by Mr. H. Matheson, D.L.S. The principal work consisted in locating a road along Fiddle Creek canyon from the Grand Trunk Pacific station

to Miette Hot Springs, about eleven miles distant. The district is so rough and mountainous and the sides of the canyon so precipitous that much contour work was necessary and progress was slow.

Mr. J. A. Fletcher, D.L.S., took latitude observations on the second, third and fifth meridians and also in the railway belt of British Columbia.

The surveys of isolated settlements along Athabaska river were performed by Mr. E. A. Neville, D.L.S. Surveys were made at Chipewyan, Smith Landing and Fort Smith.

Mr. C. M. Walker, D.L.S., retraced two townships south of Medicine Hat. He also made a restoration survey of the townsite and villa lots at Banff, extended the townsite and surveyed the roads constructed around Banff, &c. The work at Banff was done for the Dominion Parks Branch, and was urgently required as applications for lots had to be withheld till the survey was completed.

Mr. L. F. Heuperman, D.L.S., who was employed for a short time only, did some subdivision northeast of Macleod.

STATEMENT OF MILEAGE SURVEYED.

The following is a comparison of the mileage surveyed each year since 1910:—

Nature of Survey.	April 1, 1910 to March 31, 1911.	April 1, 1911 to March 31, 1912.	April 1, 1912 to March 31, 1913.
	Miles.	Miles.	Miles.
Township outlines	2,376	2,041	2,718
Section lines	11,849	10,098	10,365
Traverse	2,758	2,577	3,509
Resurvey	906	2,317	2,586
Total for season	17,889	17,033	19,178
Number of parties	64	61	72
Average miles per party	279	280	266

The following tables show the mileage surveyed by the parties under daily pay and by the parties under contract:—

WORK OF PARTIES UNDER DAILY PAY.

Nature of Survey.	April 1, 1910 to March 31, 1911.	April 1, 1911 to March 31, 1912.	April 1, 1912 to March 31, 1913
	Miles.	Miles.	Miles.
Township outlines	1,178	992	1,619
Section lines	1,487	823	1,358
Traverse	462	498	992
Resurvey	835	2,237	2,538
Total for season	3,962	4,550	6,507
Number of parties	30	29	35
Average miles per party	132	157	186

WORK OF PARTIES UNDER CONTRACT.

Nature of Survey.	April 1, 1910 to March 31, 1911.	April 1, 1911 to March 31, 1912.	April 1, 1912 to March 31, 1913.
	Miles.	Miles.	Miles.
Township outlines	1,198	1,049	1,099
Section lines	10,362	9,275	9,007
Traverse	2,296	2,079	2,517
Resurvey	71	80	48
Total for season	13,927	12,483	12,671
Number of parties	34	32	37
Average miles per party	410	390	342

Owing to the nature of their work, ten parties are not included in the statement of mileage for the year ended March 31, 1913.

COST OF SURVEYS.

The following statement shows the average cost per mile of surveys executed by surveyors under daily pay and by surveyors under contract:—

—	Surveyed under daily pay.	Surveyed under contract.
Total mileage surveyed	6,507	12,671
Total cost	$455,780	$325,882
Average cost per mile	$70.05	$25 72

STANDARDS OF LENGTH.

The business of a land surveyor being to measure land, the first requisite of his profession is a correct measure. In the early days of Canada every surveyor upon receiving his commission was furnished by the Secretary of the Board of Examiners with a wooden yard by means of which he was directed to verify his chains. The length of a wooden rod is affected by moisture, heat and other causes; even if the length were correct, the accurate verification of a surveyor's chain by means of a yard requires elaborate apparatus and installations not usually at the disposal of surveyors. Such tests as a surveyor is able to make with a yard are suitable only for measurements of a rough character. One of my first acts in assuming the direction of Dominion Lands Surveys over thirty years ago, was to recommend the substitution of an adequate Standard of length, properly tested, in the place of the wooden yard Standard. I never ceased to urge the great importance and absolute necessity of this reform and I am glad to say that in a few months it will at last be accomplished. An account of the steps taken in endeavouring to obtain this reform is set forth in a resolution adopted by the Board of Examiners for D.L.S., on March 7, 1905. It is as follows:—

'Prior to 1886, the Dominion Lands Act required every Dominion Land surveyor to be in possession of a standard measure of length which was to be furnished to him

by the Department of Inland Revenue on payment of three dollars. The Standards, which were three feet pine rods, were of little or no use to surveyors and as no penalty was provided by the Act, few surveyors, if any, procured them.

In 1885, the Board of Examiners for Dominion Land Surveyors, impressed with the necessity of supplying adequate standard measures to surveyors, recommended that a line measure consisting of a 66 feet steel band be substituted in the place of the 3-feet wooden rod and that the Act be amended to provide that such measure should be furnished to surveyors by the Secretary of the Board, after being tested and stamped by the Department of Inland Revenue. A penalty of twelve months suspension was suggested for surveyors not complying with the law. These amendments were adopted by Parliament during the session of 1885-86 and assented to in June, 1886. The steel bands were immediately procured and the Board of Examiners deputed one of its members, Mr. W. F. King, to ascertain whether the Department of Inland Revenue had a suitable comparator for testing such measures. Mr. King interviewed Mr. Miall, Commissioner of Inland Revenue, who referred him to Mr. Johnstone, Chief Inspector of Weights and Measures. Mr. King was shown a comparator for testing end measures: he pointed out that it was not suitable for testing line measures such as those to be furnished to surveyors, and asked whether another comparator could be set up. Mr. Johnstone's reply was in the negative. It appeared from the conversation that the Department of Inland Revenue had for some time been asking a special building for their standards but so far had not succeeded in having it provided for in the estimates. When they obtained such a building, they would provide a suitable comparator, but not before. Thereupon, the board adopted a resolution recommending that the law be amended so as to place the testing of these measures under their own control and that the purchase of a comparator be authorized. Before acting upon this resolution, the Deputy Minister of the Interior communicated with the Commissioner of Inland Revenue and was informed that the comparator would be procured and set up.

Then followed a period of five years during which the Department of Inland Revenue alternately refused and agreed to set up the comparator until it was finally set up in 1891. The plans had been furnished by the Surveyor General, but the workmanship was so rough that the tests were never satisfactory. However, it was used for some years, one hundred and thirty-five measures being tested and issued to surveyors.

The uncertainty of measurements under these conditions may be illustrated by the experience of Mr. A. O. Wheeler, one of the surveyors of the Department of the Interior, with a 100 metres tape. A test of this tape was furnished by the manufacturers, Messrs. Keuffel & Esser, of New York, and another test by the United States Coast and Geodetic Survey. It was also compared with Mr. Wheeler's subsidiary standard which had been tested once by the Department of Inland Revenue and twice by this Board. The five comparisons reduced to the same temperature and tension show the tape to be too long as follows:—

Keuffel & Esser..	0·194 inch.
U. S. Coast and Geodetic Survey..	0·946 "
Department of Inland Revenue..	1·498 "
Board of Examiners for D.L.S., first test..	2·073 "
Board of Examiners for D.L.S., second test..	2·307 "

The above figures show an uncertainty of over two inches in the length of this tape, equivalent to about three feet per mile. How unsatisfactory this is may be understood when it is stated that on well equipped comparators tests are now made with a precision equivalent to one or two-tenths of an inch per mile. Such an extreme precision is not required by surveyors in the ordinary practice of their

profession, but it is not unreasonable to ask for them an accuracy of one-fiftieth of an inch for a 66 feet tape, which is equivalent to 1·6 inches per mile.

A rough wooden shed for the comparator had been put up on an ordnance lot on Cliff street. The door was closed with a cheap padlock and light given through a few small windows without shutters. In 1902, or thereabouts, the place was entered by boys who broke the windows, stole seven steel bands and parts of the comparator, broke the thermometers and left everything in confusion. It was stated by the Deputy Minister of Inland Revenue that steps would be taken to replace the missing parts and to put the comparator in proper shape again but this has not yet been done and the tests of the measures furnished to surveyors since 1901 are not, in the opinion of the Board, sufficiently accurate to meet the requirements of the profession. The Surveyor General interviewed recently the Chief Inspector of Weights and Measures and was informed that the comparator on Cliff street would not be repaired but that one would be placed in a building to be erected for the standards. In the meantime, the measures would be tested on a mural standard back of the Langevin Block.

It is thus seen that we have come back to the point we started from nineteen years ago: the present Chief Inspector states, as Mr. Johnstone did then, that a suitable comparator will be provided when a building is erected for the standards. The Board is of the opinion that such a condition of affairs should not be allowed to continue any longer and that steps should be taken immediately to furnish to surveyors measures tested with sufficient precision for the purpose of their profession. After full consideration and discussion, the Board have come to the conclusion that the matter will not be properly attended to until it is placed under their control: therefore they recommend that the Dominion Lands Act be amended accordingly and that authority be granted for the establishment of a suitable comparator.'

The Chief Inspector of Weights and Measures was quite right in declining to test our measures until a building was provided. Control of the temperature is essential for proper tests; its variations must be extremely slow. This requires a substantial building; without it the accuracy of the tests would have been illusory.

The amendment to the law was not made until March, 1908, when the Dominion Lands Surveys Act was assented to. Section 35 of the Act directs the Surveyor General to furnish standard measures to surveyors and to make the necessary tests of these standards.

The next thing to be done was to erect a building for the installation of the testing apparatus so that the directions of the law could be carried out. Provision for the erection of the building was made in the estimates for several years in succession, but it was not commenced until last year. It is nearly finished. It is expected that the comparator will be installed and measures tested before the end of the summer.

The comparator was designed under the direction and according to the indications of Mr. Chas. Ed. Guillaume, Assistant Director of the International Bureau of Weights and Measures, who is probably the greatest living authority on questions relating to the measurement of lengths.

The plans were made and the apparatus constructed by the 'Société Genevoise pour la Construction d'Instruments de Physique et de Mécanique,' a firm which has made a specialty of this kind of apparatus. The comparator consists of a four metres invar rule divided into millimetres, borne by a carriage which moves upon rails opposite reference marks attached to concrete piers. The length, of the base, 32 metres, is sufficient for testing directly English measures up to 100 feet. The section of the invar rule, something like the letter 'h,' is entirely new. The apparatus, which is very elaborate, is provided with all the appliances necessary for convenience in handling and accuracy in results. The thanks of the Department are due to Mr. Guillaume for devising the apparatus, directing its construction, standardizing the invar rule, testing

and calculating tables of corrections for the precision thermometers, and helping us in many other ways.

The new subsidiary standard is a steel tape one-quarter inch wide, 0·012 inch thick and a little over 66 feet in length. On one side, at every ten links, one-tenth of a link is divided into hundredths and half hundredths. On the other side, at every ten feet up to 50 feet, one-tenth of a foot is divided into hundredths and fifths of a hundredth. The graduations, which are engraved, are very fine. A tension handle is provided for applying the tension of 10 pounds under which the tape is tested and certified. The standard is made by the Lufkin Rule Company of Canada; its perfection and accuracy are remarkable. The company fully realize the need and importance of an accurate standard; the surveying profession is indebted to them for their hearty co-operation in producing it.

ERRORS IN DOMINION LANDS SURVEYS.

Nearly nine-tenths of the existing surveys have been executed under my direction. When I took charge, the subdivision surveys had barely crossed the western limit of Manitoba; they now spread from Ontario to the Pacific Ocean and to township 110 in the north.

Under the provisions of the first Dominion Lands Act, a quarter section was held to contain 160 acres, whatever might be the actual contents. It followed that a section side was held to be one mile in length and was so returned by the surveyors. Four directions, no more, were admitted for section or township lines and entered by surveyors in their field notes, namely, north, south, east and west. Although the law has been changed on my recommendation and surveyors now return in their field notes what they actually find, the principle of the old law was sound. It makes absolutely no difference to a farmer whether his quarter section contains 159 or 161 acres; by calling the area 160 acres and the section side one mile, a great simplification was introduced in all land transactions. Evidently, the Surveyor General, Col. Dennis, when drafting the first Dominion Land Act, expected that the discrepancies of the survey could be kept within narrow limits and that is where the principle failed. As time went on, we heard of discrepancies sometimes exceeding a quarter of a mile, where, according to the surveyor's field notes, everything was perfectly regular. These errors appear to be spread all over Manitoba. In extending the surveys west of Manitoba, discrepancies of a like nature, although on a smaller scale, were met with; they were located and corrected by astronomical observations. Measuring on the earth by means of the stars is a roundabout way of finding distances and not a very accurate one, but it was the best we could do. We thus managed to keep errors within bounds outside of Manitoba. On reaching Peace river, we were a quarter of a mile out, but Peace river is a long way off; the error was corrected later. So far as we are able to judge, and with the exception of lower Peace river, which has not been checked, few if any township lines outside of Manitoba are more than 200 feet out of position.

For a long time, the condition of affairs in Manitoba was utterly incomprehensible; errors would crop up in the most unexpected places. In starting from a township corner and steering for the next one, we were never sure we would hit it or anywhere near it. The field notes of the old surveys, in which the entries were often purely conventional, afforded very little assistance. The trouble was attributed to the carelessnes and incompetence of early surveyors, but even if it had been understood it was too late for making corrections, because the lands had been taken up and their boundaries could not be changed. The climax happened when the principal meridian was produced northerly across lake Winnipeg for the purpose of surveying lands along the Hudson Bay railway; it was found by astronomical observations that township 35 was one-third of a mile too far north. A connected system of survey could not be carried out with errors of this magnitude in the short space of 35 townships,

and so it was decided to find out what the trouble was by going over the old lines right from the beginning. This was done last year by Mr. A. G. Stuart, who retraced the principal meridian from the international boundary to township 28. Then came the astonishing discovery that the errors were mostly due to the use of incorrect measures. The old surveyors were not to blame, but their chains were wrong and this was because the means of verification furnished to them were inadequate. The evidence is incontrovertible. Milner Hart, for instance, in laying out fifteen townships in 1871 made all his miles within a few links of the same length, which is proof of careful chaining, but every mile is 13 feet too long, which shows that his chain was two inches too long. It may be asked how it could possibly be so much in error. If Milner Hart verified his chain by stretching it on the prairie and measuring it with the wooden yard, furnished to him as a standard, the error on each yard length was less than one-tenth of an inch and is perhaps not more than was to be expected under the circumstances and with such rudimentary means of verification. If the measurements had been continued with that same chain up to Peace river or the Pacific Ocean, the township lines would have been nearly three miles out of position. If all the chains had been equally wrong, there would have been no difficulty; the townships and sections would have beeen square and all of equal size, without gap or overlap anywhere. But the chains were of various lengths; there were even some that were correct. The conditions can now be easily understood. Between the lines run westerly from the principal meridian and those run easterly from the second meridian upon which lengths are about correct, there is a gap which varies all the way from a few chains to 26 chains. This is not all; the base lines running east and west are affected by the same causes as the meridians and produce another set of discrepancies. The result of the whole is inextricable confusion.

It is unfortunate that surveyors were not at the outset provided with adequate means of verifying their chains. If lengths had been correctly measured, the land survey of the Dominion would have been the most perfect and remarkable one in the world.

CORRESPONDENCE.

The correspondence of this Branch consisted of:—

Letters received	12,598
Letters sent	16,600

ACCOUNTS.

Number of accounts dealt with	1,280
Amount of accounts	$976,436
Number of cheques forwarded	3,630

CHIEF DRAUGHTSMAN'S OFFICE.

(T. Shanks, Chief Draughtsman.)

In last year's report reference was made to the difficulty of carrying on efficient work owing to the many changes in the staff. As a result of these changes the unsatisfactory condition of the technical staff deserves serious consideration. It is becoming more difficult every year to have the office work attended to and it is falling in arrears. Only the immediate demands of the public can be dealt with under present conditions and even these cannot in many cases be given the consideration they deserve. It follows that much interesting and valuable information collected at great cost by the

surveyors cannot be made available for the public because we have not enough employees to compile it from the reports and field notes. Unless some measure of relief is obtained soon, the situation will get beyond control.

The technical staff consists of 93 men, or rather should consist of 93 men if all the vacancies were filled, but appointments cannot be made fast enough to fill the places of those who are leaving to do better elsewhere and who, as a rule are the most useful and efficient of our men. Many of the nominees of the Civil Service Commission after becoming aware of the prospects offered, decline the appointment. Others stay a few months and resign or are transferred to other offices.

In the past, applicants for positions in the office have been selected in most cases from graduates of recognized universities, preference being given to men who have some special training in mathemathics or engineering. During the last few years we have not been able to induce a sufficient number of competent men to accept employment or to remain in the service after appointment. Since May 1, 1910, the Civil Service Commission has been asked for the appointment of 65 technical clerks. From the applications received, 71 men with the required qualifications were selected but only 58 reported for duty and of these only 31 are at present on the staff. The fact that we are not able to obtain a sufficient number of qualified men to fill vacancies shows that the initial inducements are not attractive enough and the fact that we cannot retain the men who are appointed proves that the prospects for advancement are not to be compared with those of similar positions outside our service.

The duties of the technical staff may be classified under four heads, viz.:

1. Drafting instructions to surveyors.
2. Checking the work of surveyors, pointing out their mistakes and the corrections required.
3. Plotting the surveys and issuing the plans.
4. Furnishing technical information to other Departments and to the public.

The technical employee must be at least as well qualified as the surveyor if he is to tell the latter how his survey is to be made, but while the surveyor is paid at the rate of $3,100 to $4,500 a year, the technical employee is appointed at $1,200 a year with very remote prospects of ever advancing beyond $1,600. That the surveyors are not paid too much is proved by the fact that the number of recruits is barely sufficient for the needs of the service. In the West, the regular salary of a provincial land surveyor is fifteen dollars per day. The disproportion in the remuneration of the technical employee, who is fully as well qualified as the surveyor, explains why his services cannot be retained.

The consequences of this policy are manifold. A surveyor may be waiting for instructions because no competent employee is available to draft them; it would be cheaper to pay a fair salary to an employee than to keep a whole survey party idle. Or it may be that some plotting or other work has to be done before the survey can be proceeded with. If done by the surveyor while his party is waiting, it will cost $40 to $75 per day according to the size of the party. It could be done here by an employee at five or six dollars per day, but to have it done at $3.50 per day is a hopeless task. Many instances could be cited where the present organization of the staff is a cause of great waste, but the worst feature is the baneful effect on the surveys administration generally.

As the past decade has been one of remarkable activity in western Canada, the surveys of Dominion Lands have had to keep pace with the rapid progress in settlement and industrial development. To lay out the land ahead of the homesteader, the miner and the lumbermen has necessitated the organization of a large field staff, directed from the head office. This meant constantly keeping in touch with a widely scattered corps of surveyors, furnishing them with detailed instructions for their work and examining their field notes to see that the surveys were satisfactorily made.

The magnitude of this work may be judged from the following statement showing the number of surveyors employed for the past ten years:

Year.	On day pay.	On Contract.	Total number of surveyors employed.
1903	16	53	69
1904	25	57	82
1905	29	20	49
1906	35	29	64
1907	33	30	63
1908	39	31	70
1909	38	26	64
1910	39	34	73
1911	41	33	74
1912	44	37	81
Total	339	350	689
Average	34	35	69

While the extent of the surveys performed is a fair indication of the amount of office work for the year, it cannot be accepted as an accurate guide. The problems of survey work grow in complexity as settlement increases and this is true not only of field work but of questions of office administration. The surveys of early years were confined to township subdivision on the prairie. The instructions were simple, the work in many cases was performed by men who possessed neither lengthy experience nor special technical knowledge and the examination of the notes and plans was made with little attention to detail. As a result of settlement and the consequent increase in the value of the land, many things that were overlooked in the surveys of thirty and forty years ago have come to light. These frequently lead to disputes among settlers and to much investigation on the part of the Department and the errors are often difficult and sometimes impossible to correct. The law provides for corrections under certain conditions and an attempt is made to remove the trouble in every case where there is a possibility of this being done.

Among the other phases of work which have developed during recent years may be mentioned the growing demand for special settlement and townsite surveys, the greater attention given to exploratory and purely topographical work, the examination of railway and highway plans and the constantly increasing correspondence with the public and with surveyors in private or provincial practice who depend upon this office to furnish information about surveys already made. The research work entailed in collecting data from old survey records is not always easy and is further complicated by the fact that the offices of the Department are not accommodated in one building.

FIRST SECTION—SURVEY INSTRUCTIONS AND GENERAL INFORMATION.

(H. G. Barber, Chief of Section.)

The work performed in this section consists, in general, of the preparation of instructions for the surveyors in the field, the entering of all survey returns in the various registers, the issuing of all preliminary plans except for the townships in the railway belt of British Columbia, the issuing of the Annual Report of the Branch, and the answering of requests for information received from the general public and from other Branches and Departments.

Two hundred and fifty-five drafts of instructions were issued involving the preparation of 2,019 sketches and 253 maps and tracings.

One thousand four hundred and fifteen communications from settlers and others and inquiries from other Branches and Departments were dealt with. This necessitated the preparation of 1,830 sketches, 181 plans and tracings and 368 pages of field notes. Two thousand and twenty-nine copies of sketches were also made for the information of other Branches.

Preliminary plans were issued for 282 townships. Four copies of each are prepared, one copy being placed on file in this office, and one each being furnished to the Survey Records Branch, the Land Patents Branch, and the land agent in whose district the township lies.

Plans of 517 townships and 9 townsites and settlements were received from the lithographic office as well as 84 sectional maps and 153 miscellaneous plans.

The office registers show that there were received from the surveyors in the field, 1,372 progress sketches, 336 books of field notes for township surveys, 299 books and 254 plans for miscellaneous surveys, 210 timber reports, 176 statutory declarations, and returns for 73 magnetic observations and for 13 timber berths. General reports on their survey operations were received from forty surveyors.

Their examination being completed, 431 field books of township surveys and 52 books and 138 plans of miscellaneous surveys were placed on record.

The number of files received from the Correspondence Branch for use in the work of the office was 1,845.

The total number of draft letters and memoranda was 6,322.

The preparation of the new edition of the Manual of Instructions for the survey of Dominion Lands was completed during the year. It is now in the hands of the printers and it is expected that it will be issued shortly.

A new edition of the pamphlet entitled 'Description of the surveyed townships in the Peace River district in the provinces of Alberta and British Columbia' has just been prepared. It is now ready for the printers and is expected to be ready for distribution in a couple of months.

A new feature of the work of the section was the preparation of topographical maps of Banff, Woodhaven and Fitzhugh townsites and of Bankhead cemetery on which schemes of subdivision were laid down and from which working plans for the surveyor were prepared. This involved a large amount of work requiring the full time of three draughtsmen for about three and one-half months. The plans for Bankhead cemetery and the townsites of Woodhaven and Banff have beeen completed but considerable work still remains to be done in connection with Fitzhugh and the villa lot section of Banff.

For some time this staff has been labouring under the handicap of insufficient accommodation, it being necessary to have some of the members working in the rooms belonging to other sections. This, however, has been remedied. During the year the staff of Section IV removed to the Imperial Building and the room formerly used by them is now occupied by part of this staff.

The strength of the staff is 24 and in addition there is at present one temporary employee. This is four short of the required number and as a result a good deal of the less urgent work has had to be laid aside for the present.

SECOND SECTION—EXAMINATION OF RETURNS OF SURVEY.

(T. S. Nash, Chief of Section.)

In this section examination is made of the returns of survey of all Dominion Lands other than those in the railway belt in British Columbia and the necessary plans thereof are prepared.

As soon as a surveyor completes the survey of a township, or a portion thereof, he forwards a sketch showing the progress of his work. These sketches are examined to see that correct methods are being employed and that satisfactory results are being

obtained. 375 progress sketches from contractors, 532 from men employed by the day, and 195 from inspectors of contract surveys were examined making a total of 1,102 sketches.

A radical change was made in the method of dealing with water areas in the prairie provinces. Experience has shown that many of the bodies of water commonly called lakes are not permanent bodies of water since they vary largely in area according to the amount of annual precipitation. Surveyors define the position of the banks of these bodies of water to the best of their ability at the time of survey and in the preparation of the township plans areas have heretofore been calculated to the bank. This variable bank has not proved a satisfactory boundary and it has now been decided to use the information supplied by the surveyor to make a selection of certain aliquot parts of the quarter sections adjoining such bodies of water and to show the areas of these parts upon the plans for purposes of disposal. This change in method necessitated the changing of about two hundred plans that had been completed in the former way. It was also decided to omit the areas of patented lands from plans that are being amended. This involves considerable clerical work in obtaining the information to the date of confirmation of the plan. These changes have made it advisable to resume the practice of re-compiling plans that are out of print. 602 township plans were compiled, 290 of which were first edition plans.

Examination was made of 206 subdivision surveys, 142 miscellaneous and 274 township outlines. Compiled plans of 63 miscellaneous surveys, 4 settlements and 16 timber berths were made. Four hundred and thirteen memoranda on examination of survey returns were sent to surveyors and 446 replies were received and the necessary corrections made. The number of draft letters prepared was 1,520. Thirty-nine contract accounts were prepared and closed as the work was shown by the inspectors' report to be satisfactorily performed.

Considerable progress was made with the maps of the Yukon Territory mentioned in last year's report. Eight sheets in the vicinity of Dawson are now completed, three at Tantalus and a chain of five sheets between Whitehorse and the British Columbia boundary. Six group lot surveys and the survey of base lines on several tributaries of Stewart river were examined.

Requests for information from other Branches of the Department involved the writing of 288 memoranda, the preparation of 137 sketches, and the calculation of 940 areas. The field notes were examined and plans prepared for 16 timber berths comprising 27 blocks whose boundaries totalled 255 miles of survey and whose area is approximately 98 square miles. The returns of nine other timber berths were examined also.

The plans of road diversions submitted by the Provincial Governments have been examined to the number of 341. Of railways 155 plans of right-of-way were examined, the mileage of which is 2,891. As many of these plans were in duplicate, or triplicate, the gross mileage of plans examined was 4,418.

A great deal of time has been spent upon the preparation of a topographical map of the valley of Fiddle creek in Jasper Park, and on the preparation of a new plan of the town of Banff.

Five men resigned from the staff during the year and two were appointed, the staff now consisting of 23 permanent clerks and two temporary employees.

THIRD SECTION—DRAWING FOR REPRODUCTION.

(C. Engler, Chief of Section.)

The work of this section consists in drawing plans for reproduction by photography and lithography, and of any work of like nature arising in the other sections of this Branch of the Department. Wherever possible, letters and figures are made by means of type, a small press or small tripods being used for printing.

The output of plans of townships, the main work of the section, has been somewhat smaller than usual owing to changes made in the method of representing lake shores and areas bordering on lakes. Before a satisfactory way of showing these was arrived at several of the first methods had to be abandoned after considerable work had been done on plans in each case. Generally speaking, plans of resurveys and corrected editions of plans are more complicated than first editions and require more time and special attention to exceptional details, not going so regularly through the ordinary routine.

Below is a statement of work done.

Plans of townships prepared for printing	538
Plans of settlements, subdivisions, group lots, townsites, villa lots, &c	69
Plans to accompany Orders in Council	13
Miscellaneous plans, such as timber berths, sketch maps, profiles, drawing of apparatus, &c	117
Surveying instruments and steel tapes engraved with numbers or monograms	117
Certificates and Commissions engrossed for Board of Examiners for Dominion Land surveyors	56
Colored designs for pamphlet covers, sketches for half tones for pamphlets, &c	20
Total	930

No changes in the regular staff have occurred during the year, but five additional temporary clerks have been employed since January 1, 1913.

FOURTH SECTION—SURVEYS IN THE RAILWAY BELT—BRITISH COLUMBIA.

(E.L. Rowan-Legg, Chief of Section.)

The work of this section has been the preparing of preliminary plans from sketches sent in by surveyors, showing the progress of their work in the field, the examination of surveyors' field notes and plots, the compiling of township and other plans, the comparing of fair copies of township and other plans and replying to requests for various information.

The work done has been as follows:—

Preliminary plans compiled 52, and copies made 260; surveyors' field books of subdivision surveys examined 27, and plots 29; of mineral claims 3; of miscellaneous surveys 13; township plans compiled 98; townsite plans compiled 2; miscellaneous plans compiled 2; fair copies of compiled plans compared 131; various plots and sketches made 142; odd jobs and requests for various information dealt with 312; draft letters and memoranda written, 341.

A schedule of Indian reserves was prepared to accompany a report of the Minister of the Interior recommending that the lands included in these reserves be withdrawn from the operations of the regulations for the administration and disposal of lands within the railway belt. This recommendation was approved by Order in Council of January 25, 1913.

The staff of this section consisted of seven men, but this number was reduced by the removal of one to another section of the Branch, the absence of two for a considerable length of time on sick leave, and by the illness and death of Mr. Henry Lawe, D.L.S., who was a faithful and most industrious member of this staff for nine years. The staff, therefore, is reduced to five men.

As it was found that the building on Metcalfe street was too crowded, it was considered advisable that this staff should be moved to other quarters; it now occupies a room in the Imperial Building on Queen street.

FIFTH SECTION—MAPPING.

(J. Smith, Chief of Section.)

The work of the fifth section is principally on the sectional maps, compiling new ones as required and revising old ones, keeping them up to date as to new surveys, railways, post offices, &c., and also making other maps that require the work of expert draughtsmen.

Apart from the sectional maps, work, equivalent to the work of one man for 245 days, was done by this section on miscellaneous drawings to accompany reports of surveyors, and 28 days were spent in revising the map of the Peace River district.

On January 1, 1913, the staff of this section was increased by the transfer from the Sixth Section of four men whose principal work is the compiling of pamphlets descriptive of the newly surveyed districts of the western provinces. The pamphlets contain not only all the reports received from surveyors between July, 1911, and July, 1912, but also all the available information respecting the natural features and resources of the district.

All available information was collected and edited for the St. Ann, Saddle Lake, Shell River, Brule and Duck Mountain pamphlets which contain descriptions of one hundred and twenty-three townships each.

The staff of this section now numbers seventeen.

Illness and accidents caused loss of work during the year equivalent to the work of one man for 345 days, which is about 8½ per cent of the aggregate time of the staff.

SIXTH SECTION—SCIENTIFIC AND TOPOGRAPHICAL WORK.

(G. Blanchard Dodge, Chief of Section.)

The work performed in general in this section consists of issuing instructions for and plotting returns of levels on meridians and base lines, checking and reducing magnetic observations, calculating astronomical field tables, testing and adjusting survey instruments, and preparing and issuing the pamphlets containing surveyors' township reports, &c. The level work was in large part transferred in the early part of the year to the Calgary office of the Branch. The preparation of the pamphlets containing the surveyors' township reports was on December 31, 1912, transferred to the Fifth Section.

The number of magnetic declination returns received for the year ended March 31, 1913, is 1,278, making a total to date since 1908 of 4,114. Dip and total force observations for the year number 30, with a total of dip observations since 1908, of 144, and of total force observations 120. A statement of the observations for the past year is published with this report.

In Appendix No. 50 of the Annual Report of the Branch for 1911, on the determination of the magnetic declination, dip and total force in Western Canada, in Table No. 3, the logarithms of the total intensity are given instead of the natural values. The Table has been reprinted and accompanies the statement of the declination observations in the present report.

The computations of the triangulation in the railway belt of British Columbia are in hand. It is expected that full information for that portion extending from the Salmon Arm base to the Kootenay base will be available during the coming winter.

All the returns of azimuth observations for the year 1911 received during 1912 have been examined and checked and also the latitude observations of Mr. J. A.

Fletcher, D.L.S., taken during 1912. The astronomical field tables for the year have been computed.

The following reports of townships have been compiled from the surveyors' reports and sent to press from April 1, 1912, to December 31, 1912.

1. Reports on townships east and west of the Principal Meridian and west of the Second Meridian.
2. Reports on townships west of the Third Meridian.
3. Reports on towships west of the Fourth Meridian.
4. Reports on townships west of the Fifth and Sixth Meridians.
5. Reports on townships in the railway belt, B.C.

The work done at the Surveys Laboratory for the past year, includes the testing and adjusting of 10 block survey transits, 72 subdivision transits, 60 sidereal watches, and 62 subsidiary standards of length.

The number of letters received during the year was 450 while the number of letters sent was 1,203, besides 380 memoranda. Sixty letters of instructions to surveyors were prepared.

The staff at the close of the fiscal year consisted of seventeen permanent and three temporary clerks.

PHOTOGRAPHIC OFFICE.

(J. Woodruff, Chief Photographer.)

The work of the Chief Photographer shows a slight decrease in the total number of jobs for the year. This, however, is more than compensated for by the fact that there has been a very large increase in the number of Vandyke and blue prints made, and these are of much larger size than those of previous years.

A new Enlarging Camera is under construction capable of taking negatives up to 20 inches instead of 14 inches as in the present camera. This will facilitate bromide enlarging, and permit of much quicker and better work being done.

PHOTOGRAPHIC OFFICE.

(H. K. Carruthers, Process Photographer.)

While the negatives and photo-liths appear to be smaller in number this year than last, the fact must not be overlooked that we are now handling much larger plates An original which previously took four (4) 15 x 18 inch negatives is now made on a 24 x 32 inch plate, and the same procedure is followed in printing on zinc plates.

A new board of unique type has been placed on the copying camera. On the back is a frame made of steel angle iron with cross bars. By the adjusting of some twenty fine threaded screws, the whole surface of the board can be made perfectly flat.

Millimeter scales of brass have been added to the scaling rod making our reductions and enlargements more accurate.

A plate glass fifty inches square in a sliding frame hung from the steel rails above, keeps the copies in close contact with the board and is automatically held there, or released, by catches at the back.

BOARD OF EXAMINERS FOR DOMINION LAND SURVEYORS.

(F. D. Henderson, Secretary.)

The Board of Examiners held two meetings during the year. The first was a special meeting lasting from April 27 to June 1 (inclusive), 1912, during which examinations were held at Ottawa, Toronto, Calgary and Edmonton. The second was

the regular annual meeting which began February 10 ('the second Monday in the month of February' as provided in the D.L.S. Act, section 9) and lasted until March 27, 1913. Examinations were held at Ottawa, Kingston, Toronto, Winnipeg, Calgary and Edmonton. Two hundred and seventy-one candidates were examined.

Following are the names of the successful candidates:

PRELIMINARY EXAMINATION (56).

Albrecht, Eric W., Ottawa, Ont.
Alport, Frederic, Orillia, Ont.
Badgley, Leonard Amey, Canfield, Ont.
Ball, Alfred Nepean, Grenfell, Sask.
Batters, G. W. Stanley, Edmonton, Alta.
Beatty, Frank Weldon, Pembroke, Ont.
Beatty, William Benjamin, Sarnia, Ont.
Bedard, Henry J., Courtright, Ont.
Bick, Arthur Hardie, Ottawa, Ont.
Bromley, Robert Cecil, Winnipeg, Man.
Brown, Ernest Frank, Ottawa, Ont.
Brownlee, William Fisher, Macdonald's Corners, Ont.
Bruynseraede, Réné Paul P. A., Edmonton, Alta.
Calvin, Collamer Chipman, Kingston, Ont.
Carson, John Alton, Vancouver, B.C.
Child, Cyril George, Calgary, Alta.
Clendinning, James, Lurgan, Ireland.
Cuthbertson, William, Perth, Ont.
Daly, William Patrick, Ottawa, Ont.
Dawson, Wilfrid Laurier, Ottawa, Ont.
Douglas, Frederick William, Toronto, Ont.
Falls, Orville M., Toronto, Ont.
French, Merritt Henry, Calgary, Alta.
Gray, Blair, Komoka, Ont.
Hughes, Charles, Calgary, Alta.
Hunt, Septimus, Calgary, Alta.
Humphreys, Wilfrid, Winnipeg, Man.
Hyatt, Albert Edward, Revelstoke, B.C.
Knight, Sydney, Edmonton, Alta.
Lumb, William Ewart, Fort Stewart, Ont.
MacDonald, Leslie Stuart, Prince Edward Island.
Macdonald, Charles Alexander, Toronto, Ont.
Masson, Duncan Morrison, Toronto, Ont.
Matheson, Alexander, Armow, Ont.
Melrose, Thomas Montague, Coaticook, P.Q.
Mitchell, John Clarence, London, Ont.
Morse, Graham Parsons, Prince Albert, Sask.
McAndrew, Joseph Benedict, St. Catharines, Ont.
McNally, Henry Augustine, Westport, Ont.
Ney, Cecil Herman, Aurora, Ont.
O'Sullivan, J. F. Blake, Quebec, P.Q.
Petrie, Edward, Ottawa, Ont.
Raley, William Emsley, Lethbridge, Alta.
Rance, Charles Clarence, Toronto, Ont.
Robinson, William Earl, Beathton, Ont.
Robinson, Edward Keith, Kingston, Ont.
Ross, William Wrighton Eustache, Pembroke, Ont.
Seibert, Percy T., Southampton, Ont.
Scott, Buckton Arthur, Edmonton, Alta.
Teare, Frank, Toronto, Ont.
Thomas, Llewellyn Olding, Westmount, Que
Venny, Leonard Thomas, Brockville, Ont
Van Patter, Hugh Stanley, Aylmer, Ont.
Watson, Frederick Errol, Toronto, Ont.
Wilkinson, Robert Greenless, Regina, Sask.
Wilson, James Clarence, Wingham, Ont.

FINAL EXAMINATION (44).

Baird, Wilmot Johnston, Scarboro, Ont.
Beresford, Henry Edward, Portage la Prairie, Man.
Buchanan, John Alexander, Edmonton, Alta.
Calder, John Alexander, Ashcroft, B.C.
Cameron, Charles Scott, Regina, Sask.
Cameron, Maxwell George, Peterborough, Ont.
Cannell, Herbert William, Ottawa, Ont.
Carscallen, Hobart Rodney, Calgary, Alta.
Carthew, John Trewalla, Edmonton, Alta.
Coltham, George William, Aurora, Ont.
Cordukes, John Philip, Ottawa, Ont.
Coumans, Oliver Frank, Chepstow, Ont.
Donnelly, Cecil, Winnipeg, Man.
Elliott, George Reginald, Goderich, Ont.
Ellis, Douglas Stewart, Kingston, Ont.
Fletcher, William Arthur, Calgary, Alta.
Johnson, Hubert Colpoys, Ottawa, Ont.
Johnston, Charles Ernest, Toronto, Ont.
Johnston, James Homer, Cottam, Ont.
Lamb, Frederick Carlyle, Saskatoon, Sask.
Macdonald, George Alexander, Muirkirk, Ont.
Malcolm, William Lindsay, Guelph, Ont.
Milliken, John Bolton, Ottawa, Ont.
McArthur, Alexander Stanley, Toronto, Ont.
McDonald, Harold French, Winnipeg, Man.
McElhanney, Thomas Andrew, Vancouver, B.C.
McKay, Robert B., Vancouver, B.C.
McLellan, Roy Alexander, Harriston, Ont.
Nesham, Edward Williams, Ottawa, Ont.
Parry, Harry, Ottawa, Ont.
Pearson, Hugh Edward, Edmonton, Alta.
Pinder, George Zouch, Edmonton, Alta.
Pounder, John Allan, Ottawa, Ont.
Ratz, John Earl, Ottawa, Ont.
Reid, John, Winnipeg, Man.
Robertson, Edgar Doctor, Edmonton, Alta.
Segre, Beresford Henry, Toronto, Ont.
Seigner, William Adam, Toronto, Ont.
Vickers, Thomas Newell, Renwick, Ont.
von Edeskuty, Joseph Otto, Vancouver, B.C.
Wadlin, Lorenzo Norette, Ottawa, Ont.
Warrington, George Albert, Winnipeg, Man.
Waugh, Bruce Wallace, Berlin, Ont.
Weld, William Elfred, Ottawa, Ont.

The answer-papers of all candidates were sent to Ottawa as usual and the reading and valuation of these formed a large part of the work of the Board. At each meeting also a complete set of question papers was prepared to be held in readiness for the next examination.

Provincial surveyors writing under section 21 of the Act, are required to produce their provincial certificates, and other final candidates are required to produce affidavits of service under articles. All such evidence was examined and passed upon by the Board. Two minors who had presented themselves for final exmanination were admitted on the understanding that in case they were successful their commissions would not issue until they became of age and furnished affidavits in the regular form.

Several applications were received from college graduates asking to be admitted to the privileges of the shorter term of service under articles as provided for by section 22 of the Act. Favourable decisions were given in the following cases:—

(*a*) Graduates of the School of Mining, Kingston, in the Power Development Course.

(*b*) Graduates of the University of Alberta, who have taken certain courses in the Department of Applied Science.

(*c*) Graduates in Civil Engineering of Dalhousie University, Nova Scotia.

A form of Instructions to Presiding Examiners was drawn up and adopted. It is hoped by this means to secure uniformity in the method of dealing with candidates and in the manner of sending in the returns, and thus to facilitate the work of the Board.

Short forms for articles of apprenticeship and for transfer of articles were drawn up. These were afterwards passed by Order in Council and are now in use. They replace forms B and E in the Appendix to the Act.

Thirty-four commissions as Dominion Land surveyors were issued to those who had passed the final examination, and had furnished oaths of office and allegiance and bonds for the sum of one thousand dollars as required by section 25 of the Dominion Lands Surveys Act.

Every Dominion Land surveyor is required to be in possession of a subsidiary standard of length (D.L.S. Act, Section 35). The issue of the style of standard which has been in use for some years was discontinued in May, and a new model was adopted which, however, was not ready for distribution until October. It is a steel tape one-quarter of an inch wide and a little over 0·012 of an inch thick. It shows links on one side and feet on the other. The new standard weighs nearly one pound less than the old; it is also more accurate and more convenient for use. Forty-seven standards were issued during the year after having been carefully tested in the Surveys Laboratory. Forty-five of these went to Dominion Land surveyors and two to provincial surveyors. A list of Dominion Land surveyors who are in possession of standard measures, will be found in Appendix No. 10.

In February the office of the Secretary of the Board was removed from the Topographical Surveys Branch, Metcalfe street, to the Imperial Building, Queen street. A more commodious room was secured which will also serve for a Board Room. A type-writer clerk has also been appointed to assist with the work.

The correspondence of the Board was as follows:—

Letters received	1,656
Letters sent	781
Circular letters, pamphlets, notices, &c., sent	1,783

The following table shows the number who have tried the various examinations each year since 1900, and the number and percentage of successful candidates:—

FISCAL YEAR.	PRELIMINARY.			FINAL.			D. T. S.			TOTAL.		
	Tried.	Pas'd.	Per cent Pas'd.	Tried.	Pas'd.	Per cent Pas'd.	Tried.	Pas'd.	Per cent Pas'd.	Tried.	Pas'd.	Per cent Pas'd.
1899-00...	7	6	86	5	4	80	0	....	....	12	10	83
1900-01...	5	5	100	5	5	100	0	....	....	10	10	100
1901-02...	30	26	87	10	9	90	0	......	......	40	35	88
1902-03...	31	22	71	8	8	100	0	....	....	39	30	77
1903-04...	43	37	86	18	13	72	0	.....	.....	61	50	82
1904-05..	57	42	74	23	20	87	1	0	....	81	62	77
1905-06...	36	25	70	27	19	70	4	....	....	67	44	66
1906-07...	20	15	75	20	15	75	1	0	.....	41	30	73
1907-08...	132	67	51	28	21	75	1	0	......	161	88	55
1908-09...	224	88	39	52	27	52	3	1	33	279	116	42
1909-10...	289	97	34	72	37	51	1	0	......	362	134	37
1910-11...	186	64	34	69	38	55	2	1	50	257	103	40
1911-12...	195	57	29	71	48	68	2	0	....	268	105	39
1912-13...	187	56	30	83	44	53	1	0	....	271	100	37

APPENDICES.

The following schedules and statements are appended:—

No. 1. Schedule of surveyors employed and work executed by them from April 1, 1912, to March 31, 1913.

No. 2. Schedule showing for each surveyor employed from April 1, 1912, to March 31, 1913, the number of miles surveyed of township section lines, township outlines, traverses of lakes and rivers and resurvey; also the cost of the same.

No. 3. List of lots in the Yukon Territory, surveys of which have been received from April 1, 1912, to March 31, 1913.

No. 4. List of miscellaneous surveys in the Yukon Territory, returns of which have been received from April 1, 1912, to March 31, 1913.

No. 5. Statement of work executed in the office of the chief draughtsman.

No. 6. List of new editions of sectional maps issued from April 1, 1912, to March 31, 1913.

No. 7. Statement of work executed in the photographic office from April 1, 1912, to March 31, 1913.

No. 8. Statement of work executed in the lithographic office from April 1, 1912, to March 31, 1913.

No. 9. List of Employees of the Topographical Surveys Branch at Ottawa, giving the name, classification, duties of office and salary of each.

No. 10. List of Dominion Land Surveyors who are in possession of standard measures.

Nos. 11 to 51. Reports of surveyors employed.

No. 52. Results of observations for magnetic declination.

MAPS AND PROFILES.

The following maps and profiles accompany this report:—

Map showing surveys to March 31, 1913.
Maps to accompany reports of surveyors.
Profiles of meridians and base lines.

I have the honour to be, Sir,
Your obedient servant,

E. DEVILLE,
Surveyor General.

TOPOGRAPHICAL SURVEYS BRANCH

SCHEDULES AND STATEMENTS.

APPENDIX No. 1.

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913.

Surveyor.	Address.	Description of Work.
Akins, J. R.	Ottawa, Ont.	Survey of the twentieth base line across ranges 18 to 26, the twenty-third base line across ranges 1 to 8 and part of range 9, the twenty-second base line across ranges 5, 6 and part of 7 and the east outlines of townships 85 and 86, range 5, and part of township 85, range 6, west of the sixth meridian. Correction survey of the sixth meridian from the twenty-second to the twenty-third base line. Resurvey in townships 75, ranges 14 and 15, west of the fifth meridian, and of the north boundary of township 84, range 4, west of the sixth meridian.
Allison, C. B.	South Woodslee, Ont	Contract No. 13 of 1912. Subdivision of townships 34, 35 and 36, ranges 16 and 17, west of the principal meridian.
Aylsworth, C. F.	Madoc, Ont.	Resurvey in township 18, range 1, east of the principal meridian, and in townships 22 and 23, range 5, west of the principal meridian. Retracement in townships 15, 16 and 25, range 6, and township 25, range 7, east of the principal meridian.
Belanger, P. R. A.	Ottawa, Ont.	Inspection of contracts Nos. 2, 4, 5 and 6 of 1911, and Nos. 16, 17, 18 and 20 of 1912. Resurvey in township 8, range 12, west of the principal meridian. Traverse of Assiniboine river in townships 8, ranges 12 and 13, west of the principal meridian. Survey of timber berth No. 1920 in township 44, range 4, west of the second meridian. Retracement survey in townships 14, ranges 5 and 6, west of the principal meridian.
Bennett, G. A.	Calgary, Alta.	Subdivision in townships 45, ranges 10 and 11, west of the second meridian. Retracement survey in township 18, range, 2, townships 21, ranges 4 and 7, township 22, range 8, township 6, range 9, township 18, range 10, township 21, range 14, township 30, range 15, township 20, range 20, township 28, range 30, townships 18 and 19, range 31, townships 18, 19 and 31, range 32, and townships 18 and 19, range 33, west of the principal meridian; township 31, range 1, townships 14, ranges 4 and 5, township 26, range 6, and townships 15, ranges 25 and 26, west of the second meridian. Correction survey

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
		in townships 9 and 10, range 17, east of the principal meridian; township 21, range 2, township 33, range 19 and township 18, range 20, west of the principal meridian; township 6, range 14, west of the second meridian. Resurvey in township 1, range 14, east of the principal meridian. Traverse in townships 21, ranges 4 and 7, and township 30, range 15, west of the principal meridian; township 34, range 1, west of the second meridian. Investigation survey in townships 15 and 16, range 4, west of the principal meridian; townships 5, ranges 15 and 16, and townships 15, ranges 25 and 26, west of the second meridian.
Berry, E. W.	Seaforth, Ont.	Subdivision surveys along the Canadian Northern railway in townships 57 and 58, range 25, townships 55, 56, 57 and 58, range 26, townships 52 and 53, range 28, townships 51 and 52, range 29, and township 52, range 30, west of the principal meridian.
Blanchet, G. H.	Ottawa, Ont.	Survey of the nineteenth base line across ranges 6 to 26, west of the fourth meridian
Bowman, E. P.	West Montrose, Ont.	Contract No. 7 of 1912. Subdivision of township 28, range 3, townships 28 and 29, range 4, and township 28, range 5, west of the principal meridian.
Brenot, L.	Ottawa, Ont.	Subdivision surveys in township 84, range 17, townships 83 and 84, ranges 18 and 19, and townships 81, ranges 25 and 26, west of the sixth meridian. Survey of the north outline of township 83, range 22, west of the sixth meridian, and the east outlines of townships 84, ranges 20, 22 and 23, west of the sixth meridian.
Bridgland, M. P.	Calgary, Alta	Survey of villa lots at Banff. Triangulation survey in the railway belt of British Columbia in the vicinity of Salmon Arm and Revelstoke.
Calder, J. A.	Lytton, B.C.	Subdivision in township 20, range 21, townships 20 and 21, range 22, townships 13, 14, 20 and 21, range 23, townships 16 and 17, ranges 24 and 25, townships 15, ranges 26, 27 and 28, and townships 15 and 16, range 29, west of the sixth meridian. Resurvey in township 21, range 22, townships 14 and 21, range 23, townships 16 and 17, range 25, and townships 15, ranges 26 and 27, west of the sixth meridian. Traverse in township 21, range 22, townships 13, 14 and 21, range 23, townships 16 and 17, range 24, townships 16, 17 and 19, range 25, townships 15, ranges 26, 27 and 28, and townships 15 and 16, range 29, west of the sixth meridian.
Campbell, A. S.	Kingston, Ont.	Resurvey of township 53, range 19, and township 49, range 20, west of the fourth meridian. Retracement survey in township 53, range 21, west of the fourth meridian. Resurvey in Lake St. Ann settlement in townships 54, ranges 3 and 4, west of the fifth meridian.

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
Chase, A. V..	Orillia, Ont..	Examination of lands in the Kamloops district of the railway belt, British Columbia, for the purpose of classification into fruit land, farming land, grazing land, timber land and worthless land.
Christie, W..	Prince Albert, Sask....	Contract No. 20 of 1912. Subdivision of townships 56 and 57, range 6, township 57, range 7, and parts of township 58, range 6, and township 56, range 7, west of the third meridian.
Cowper, G. C..	Welland, Ont..	Subdivision survey in townships 17 and 18, range 3, township 17, range 4, and townships 21 and 22, range 10, west of the fourth meridian. Retracement survey in townships 17, 18 and 19, range 3, township 19, range 4, and township 53, range 27, west of the fourth meridian. Resurvey in township 17, range 4, townships 21 and 22, range 10, and township 10, range 12, west of the fourth meridian. Traverse in township 60, range 1, and townships 64, ranges 4, 10 and 12, west of the fourth meridian. Investigation in townships 40 and 44, range 5, township 35, range 14, and townships 51, ranges 17 and 26, west of the fourth meridian.
Cumming, A. L..	Edmonton, Alta..	Contract No. 31 of 1912. Subdivision of townships 62 and 63, range 21, and townships 61, 62 and 63, range 22, west of the third meridian.
Davies, T. A..	Edmonton, Alta..	Contract No. 34 of 1912. Subdivision of townships 69 and the south two-thirds of townships 70, ranges 10, 11 and 12, and the south two-thirds of township 70, range 13, west of the fourth meridian.
Day, H. S..	Edmonton, Alta..	Contract No. 16 of 1912. Subdivision of townships 52, ranges 16 and 17, and townships 52 and 53, range 18, west of the second meridian.
Deans, W. J..	Brandon, Man..	Inspection of contracts No. 24 of 1908, No. 19 of 1909, Nos. 1, 7 and 11 of 1911, and Nos. 5, 6, 7, 8, 9, 10, 11 and 12 of 1912. Retracement survey in township 49, range 9, townships 50 and 51, range 12, and township 51, range 13, west of the third meridian. Traverse of Brereton lake in townships 10 and 11, ranges 14 and 15, east of the principal meridian. Survey of timber berth No. 1903 in townships 7 and 8, range 16, and township 8, range 17, east of the principal meridian.
Evans, S. L..	Corinth, Ont..	Subdivision in township 19, range 4, west of the fifth meridian. Survey of part of the east outline of township 20, range 6, west of the fifth meridian. Resurvey in township 13, range 14, west of the third meridian. Retracement survey in townships 6, ranges 24, 25, 26 and 27, township 7, range 28, and township 8, range 22, west of the third meridian. Traverse of Oldman river in townships 9, ranges 25 and 26, west of the fourth meridian.

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
Fairchild, C. C..	Edmonton, Alta..	Contract No. 36 of 1912. Subdivision of townships 63 and 64, ranges 5 and 6, west of the fifth meridian.
Fawcett, A..	Gravenhurst, Ont.. ..	Contract No. 11 of 1912. Subdivision of township 23, range 12, townships 23, 30, 31, 32 and 33, range 13, and the portions of townships 30 and 31, range 12, west of lake Manitoba, west of the principal meridian.
Fletcher, J. A..	Ottawa, Ont..	Latitude observations on the second meridian in township 61, on the third meridian in township 57, on the fifth meridian at triangulation station I near Calgary, on the sixth meridian in township 48, at the north end of the base line on Salmon Arm, and on Sugarloaf mountain.
Fontaine, L. E..	Lévis, Que..	Inspection of contracts Nos. 25, 26 and 28 of 1911, and Nos. 1, 2, 3 and 4 of 1912.
Francis, J..	Portage la Prairie, Man.	Contract No. 5 of 1912. Subdivision of township 21, range 11, townships 21 and 22, ranges 12 and 13, west of the principal meridian. Resurvey in township 14, range 7, west of the principal meridian.
Galletly, J. S..	Brooklin, Ont..	Subdivision in township 73, range 6, townships 108 and 109, ranges 12, 13 and 14, townships 107 and 109, range 15, township 109, range 16, townships 83 and 84, range 21, west of the fifth meridian. Survey of the east outlines of townships 108, ranges 15 and 16, west of the fifth meridian. Miscellaneous lot surveys at Peace River Crossing.
Gibbon, J..	Vancouver, B.C..	Contract No. 8 of 1912. Subdivision of township 29 and part of township 30, range 5, and townships 28 and 29, range 6, west of the principal meridian.
Grassie, C. A..	Medicine Hat, Alta....	Subdivision in townships 49 and 50, range 27, and townships 48 and 49, range 28, west of the fifth meridian; townships 45, 47, 48 and 49, range 1, and townships 45, ranges 2, 3 and 4, west of the sixth meridian. Traverse on Snaring and Athabaska rivers in township 46, range 1, west of the sixth meridian.
Hawkins, A. H..	Listowel, Ont..	Survey of the twenty-third base line from the fifth to the sixth meridian, and of the sixth meridian through townships 89 and 90.
Herriot, G. H..	Ottawa, Ont..	Survey of the principal meridian from the sixteenth base line to the northeast corner of section 24, township 72.
Heuperman, L. F.. ..	Calgary, Alta..	Subdivision in township 11, range 30, west of the fourth meridian.
Jackson, J. E..	Hamilton, Ont..	Contract No. 9 of 1912. Subdivision of townships 30, 31 and 32, range 6, townships 30 and 31, range 7, and part of township 30, range 8, west of the principal meridian.

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
Lighthall, A..	Vancouver, B.C..	Subdivision in townships 4 and 5, range 27, and township 4, range 28, west of the sixth meridian, townships 6, ranges 5, 6 and 7, west of the seventh meridian. Resurvey in township 5, range 26, west of the sixth meridian; townships 19 and 41, east of the coast meridian. Traverse in townships 4 and 5, range 26, and townships 4, ranges 27 and 28, west of the sixth meridian; townships 6, ranges 5 and 7, west of the seventh meridian; townships 11, 12 and 19, east of the coast meridian. Survey of timber berth No. 554 in township 3, range 25, and townships 3, 4 and 5, range 26, west of the sixth meridian; timber berth No. 555 in township 6, range 7, west of the seventh meridian; timber berth No. 557 in township 6, range 5, west of the seventh meridian.
Lonergan, G. J..	Buckingham, Que.. ..	Inspection of contracts Nos. 22, 25 and 26 of 1910, Nos. 20 and 28 of 1911, and Nos. 34, 35 and 36 of 1912. Resurvey in township 53, range 25, west of the third meridian; townships 63 and 64, ranges 3, 4, 5, 6, 7, 8, 9 and 10, west of the fourth meridian. Traverse in township 63, range 18, west of the fourth meridian. Survey of timber berth No. 1914 in township 42, range 6, west of the fifth meridian.
Loucks, R. W. E.. ..	Saskatoon, Sask..	Contract No. 21 of 1912. Subdivision of township 54, range 9, and townships 53 and 54, ranges 10 and 11, west of the third meridian. Survey of the east outlines of townships 55 and 56, range 10, and township 55, range 11, west of the third meridian.
MacLennan, A. L.. ..	Toronto, Ont..	Contract No. 15 of 1912. Subdivision of township 49 and the south two-thirds of township 50, range 9, townships 49 and 50, range 10, west of the second meridian. Survey of the east outlines of townships 51 and 52, range 10, west of the second meridian.
Martindale, E. S.. ..	Kingsmill, Ont..	Subdivision in townships 16 and 17, range 5, townships 17 and 18, range 6, township 18, range 7, township 19, range 8, and township 20, range 9, west of the fifth meridian. Retracement survey in townships 6, ranges 1 and 2, west of the fourth meridian. Subdivision of villa lots at Elkwater lake in township 8, range 3, west of the fourth meridian.
Martyn, O. W..	Regina, Sask..	Contract No. 17 of 1912. Subdivision of townships 52 and 53, ranges 19 and 20, west of the second meridian.
Matheson, H..	Ottawa, Ont..	Topographical surveys on the east slope of the valley of Fiddle creek in the Jasper Forest Park reserve in western Alberta. Subdivision in townships 48, 49 and 50, range 16, and township 48, range 17, west of the fifth meridian.

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
Melhuish, P.	Vancouver, B.C.	Subdivision in township 8, range 25, townships 7, 8, 10 and 11, range 26, and township 12, range 27, west of the sixth meridian. Resurvey in townships 8, 10, 11 and 12, range 26, west of the sixth meridian. Traverse in township 8, range 25, townships 7, 8, 9, 10, 11 and 12, range 26, and townships 8 and 9, range 27, west of the sixth meridian. Survey of timber berth No. 552 in township 8, range 26, and townships 8 and 9, range 27, west of the sixth meridian.
Miles, C. F.	Toronto, Ont.	Inspection of contracts No. 14 of 1910, Nos. 14 and 33 of 1911, Nos. 21, 22, 24, 25, 29 and 30 of 1912. Retracement survey in township 63, range 1, west of the fourth meridian. Traverse in township 58, range 21, west of the third meridian. Survey of Green Lake settlement in townships 61, ranges 12 and 13, west of the third meridian.
Molloy, J.	Winnipeg, Man.	Contract No. 1 of 1911. Subdivision of townships 12, ranges 13, 14, 15 and 16, and townships 11, ranges 15 and 16, east of the principal meridian.
Montgomery, R. H.	Prince Albert, Sask.	Contract No. 19 of 1912. Subdivision of townships 55 and 56, range 4, and townships 54, 55 and 56, range 5, west of the third meridian.
Morrier, J. E.	Prince Albert, Sask.	Contract No. 18 of 1912. Subdivision of townships 56, ranges 1, 2 and 3, the east halves of townships 54 and 55, range 1, and the north two-thirds of township 55, range 3, west of the third meridian.
McEwen, D. F.	Edmonton, Alta.	Contract No. 30 of 1912. Subdivision of township 63, range 19, townships 61, 62 and 63, range 20, township 61, range 21, west of the third meridian. Survey of the east outlines of townships 64, ranges 20 and 21, west of the third meridian.
McFarlane, J. B.	Toronto, Ont.	Production of the fourth meridian from the northeast corner of township 105 to the quarter section post on the east boundary of section 12, township 115, and the twenty-fourth base line across range 5 and part of range 6, west of the fourth meridian.
McFarlane, W. G.	Peace River Crossing, Alta.	Contract No. 1 of 1912. Subdivision of township 75 and the north two-thirds of townships 74, ranges 6, 7, 8 and 9, the south two-thirds of township 70, range 11, township 73 and the south two-thirds of township 74, range 12, west of the sixth meridian. Survey of the east outlines of townships 76, ranges 7, 8, 9 and 10, west of the sixth meridian.
McGrandle, H.	Wetaskiwin, Alta.	Contract No. 37 of 1912. Subdivision of township 52, range 25, and parts of townships 49 and 50, range 24, and township 50, range 25, west of the fifth meridian.

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
McMillan, Geo.	Finch, Ont.	Survey of the twentieth base line across ranges 10 to 26, west of the fourth meridian.
McNaughton, A. L.	Cornwall, Ont.	Subdivision survey in townships 46 and 47, range 19, township 47, range 20, townships 47 and 48, range 22, and townships 46 and 47, range 23, west of the fifth meridian. Mounding in townships 48, ranges 20 and 21, west of the fifth meridian.
Neelands, R.	Hamiota, Man.	Contract No. 6 of 1912. Subdivision of township 29, range 1, townships 28 and 29, range 2, and township 29, range 3, west of the principal meridian. Survey of timber berth No. 1877 in townships 24 and 25, range 4, and township 25, range 5, east of the principal meridian.
Neville, E. A.	Ruthven, Ont.	Settlement surveys at Chipewyan, Smith Landing and Fort Smith.
Palmer, P. E.	Dorchester, N.B.	Contract No. 12 of 1912. Subdivision of townships 32 and 33, range 14, township 33, range 15, and the south two-thirds of townships 34, ranges 14 and 15, west of the principal meridian.
Pierce, J. W.	Ottawa, Ont.	Contract No. 25 of 1912. Subdivision of township 56, range 15, townships 55, 56, 57, 58, and the north third of township 54, range 16, west of the third meridian.
Plunkett, T. H.	Meaford, Ont.	Production of the tenth base line across ranges 6 to 14 and parts of ranges 5 and 15, the eleventh base line across ranges 16 to 24 and part of range 25, the twelfth base line across ranges 17 to 24 and part of range 16, the thirteenth base line across ranges 28 to 32, and the fourteenth base line across ranges 28 to 31, west of the principal meridian. Also the thirteenth base line across ranges 1 to 4, west of the second meridian. Survey of the east outlines of townships 34, 35 and 36, ranges 8 and 15, west of the principal meridian. Subdivision in township 33, range 15, west of the principal meridian.
Proudfoot, H. B.	Saskatoon, Sask.	Contract No. 23 of 1912. Subdivision of township 56, range 12, and townships 53, 54, 55 and 56, range 13, west of the third meridian.
Purser, R. C.	Windsor, Ont.	Subdivision in township 32, range 10, west of the third meridian. Resurvey in township 46, range 19, and township 43, range 28, west of the second meridian; township 36, range 19, west of the third meridian. Correction survey in township 38, range 19, west of the second meridian. Retracement surveys in township 47, range 19, and township 46, range 20, west of the second meridian; township 39, range 1, township 34, range 3, township 49, range 5, township 47, range 16, townships 53 and 54, range 22, township 54, range 23, and township 53,

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
		range 26, west of the third meridian. Traverse in townships 33 and 49, range 6, township 48, range 15, township 53, range 22, and township 54, range 23, west of the third meridian. Investigation and restoration survey in townships 37 and 38, range 26, west of the third meridian; township 60, range 25, and township 50, range 28, west of the fourth meridian.
Ransom, J. F..	Toronto, Ont..	Contract No. 14 of 1912. Subdivision of township 52, range 7, and townships 50 and 51, range 8, west of the second meridian. Survey of the east outline of township 52, range 8, and the north boundary of township 51, range 7, west of the second meridian.
Rinfret, C..	Montreal, Que..	Resurvey in townships 12 and 13, range 28, and townships 13 and 14, range 29, west of the second meridian. Correction survey in township 14, range 30, west of the second meridian; townships 14, ranges 1 and 10 west of the third meridian. Restoration survey in townships 14 and 15, ranges 23 and 24, and townships 15, ranges 25 and 26, west of the third meridian. Retracement survey in townships 13 and 14, ranges 23 and 24, township 13, range 25, and township 14, range 26, west of the second meridian; townships 12, 13 and 14, range 1, and townships 13 and 14, range 2, west of the third meridian. Investigation in townships 34, ranges 14 and 16, townships 32 and 35, range 17, and townships 32 and 33, range 18, west of the second meridian. Traverse in township 34, range 16, townships 32, ranges 17 and 18, townships 12, 13 and 14, range 28, townships 13 and 14, range 29, and township 14, range 30, west of the second meridian; townships 14 and 15, range 24, west of the third meridian.
Robinson, E. W..	Ottawa, Ont..	Production of the second meridian from the northeast corner of section 1, township 68 to the northeast corner of township 83. Mounding along second meridian from northeast corner of townships 62 to the northeast corner of section 1, township 68.
Robinson, W. A..	Winnipeg, Man..	Contract No 24 of 1912. Subdivision of townships 54, 55 and 56, range 14, and townships 54 and 55, range 15, west of the third meridian.
Rolfson, O..	Walkerville, Ont... ...	Survey of the fifteenth base line across ranges 1 to 3 and part of range 4, the sixteenth base line across ranges 1 to 25, and the seventeenth base line across ranges 1 to 5, west of the principal meridian.
Roy, J. E..	Quebec, Que..	Contract No. 22 of 1912. Subdivision of townships 55 and 56, range 11, and townships 53, 54 and 55, range 12, west of the third meridian.

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
Saint Cyr, A..	Ottawa, Ont..	Survey of the third meridian from the seventeenth to the eighteenth base line and of the eighteenth base line from the third to the fourth meridian.
Segré, B. H..	Davidson, Sask..	Subdivision in townships 18, ranges 29 and 30, west of the second meridian. Restoration survey in township 28, range 18, and township 27, range 19, west of the second meridian; township 46, range 3, west of the third meridian. Resurvey in township 26, range 2, west of the second meridian; township 25, range 3, west of the third meridian. Correction survey in townships 23, 24 and 28, range 27, west of the second meridian; township 16, range 1, and township 18, range 17, west of the third meridian. Retracement survey in townships 30 and 31, ranges 26 and 27, and townships 16, ranges 29 and 30, west of the second meridian.
Seibert, F. V..	Rush Lake, Sask..	Subdivision in township 7, range 30, west of the second meridian; township 7, range 1, and townships 16 and 17, ranges 10 and 11, west of the third meridian. Resurvey in township 11, range 12, and township 16, range 13, west of the third meridian; townships 2 and 3, range 15, west of the fourth meridian. Correction survey in township 24, range 25, west of the second meridian; township 26, ranges 13 and 20, west of the third meridian; township 38, range 11, township 24, range 12, townships 26, 27 and 43, range 14, and townships 26 and 27, range 15, west of the fourth meridian. Retracement survey in township 27, range 14, west of the second meridian; townships 19 and 20, range 15, and townships 17 and 18, range 17, west of the third meridian. Restoration survey in townships 2 and 3, range 14, west of the fourth meridian. Traverse in township 26, range 7, and townships 16, ranges 16, 17 and 21, west of the third meridian; township 8, range 3, township 38, range 11, and townships 48 and 49, ranges 22 and 23, west of the fourth meridian; township 8, range 5, west of the fifth meridian. Contour survey at Elkwater lake in township 8, range 3, west of the fourth meridian.
Soars, H. M. R..	Edmonton, Alta..	Contract No. 4 of 1912. Subdivision of townships 69, 70 and 71, ranges 22 and 24, townships 69 and 70, ranges 23 and 25, and the south two-thirds of township 71, range 23, west of the fifth meridian. Survey of the east outlines of townships 72, ranges 22, 23, 24 and 25, and townships 71 and 72, range 26, west of the fifth meridian.
Starkey, S. M..	Cody's, N.B..	Contract No. 26 of 1912. Subdivision of townships 59, 60, 61 and 62, range 16, and township 61, range 17, west of the third meridian.

APPENDIX No. 1—*Contiuned.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
Steele, I. J..	Ottawa, Ont..	Contract No. 32 of 1912. Subdivision of townships 61, 62 and 63, range 23, townships 63, 64 and the north third of township 62, range 24, west of the third meridian. Survey of the east outline of township 64, range 23, west of the third meridian.
Stewart, A. G..	Edmonton, Alta..	Contract No. 3 of 1912. Subdivision of township 81, range 18, the south two-thirds of township 82 and part of township 81, range 19, townships 82 and 83, range 20, townships 84, ranges 22, 23, 24, 25 and 26, west of the fifth meridian; townships 80, ranges 1 and 2, west of the sixth meridian. Survey of the east outlines of township 84, range 20, and township 81, range 21, west of the fifth meridian.
Stewart, N. C..	Ottawa, Ont..	Subdivision in townships 28, ranges 17 and 18, townships 28 and 29, ranges 22 and 23, township 31, range 25, and townships 31 and 32, range 26, west of the fifth meridian; townships 18 and 19, range 7, townships 18 and 20, range 8, township 19, range 9, and townships 17, 18 and 19, range 10, west of the sixth meridian. Resurvey in townships 28, ranges 17 and 18, townships 28 and 29, ranges 22 and 23, and townships 27, ranges 25 and 26, west of the fifth meridian; townships 18, ranges 7 and 8, townships 18, 19 and 20, range 9, and township 17, range 10, west of the sixth meridian. Traverse in townships 28, ranges 17 and 18, townships 27 and 28, range 22, townships 28 and 29, range 23, townships 27 and 31, range 25, and townships 27, 31 and 32, range 26, west of the fifth meridian; township 18, range 7, and township 17, range 10, west of the sixth meridian.
Stewart, W. M..	Saskatoon, Sask..	Contract No. 28 of 1912. Subdivision of townships 63 and 64, range 16, and townships 62, 63 and 64, range 17, west of the third meridian.
Stock, J. J..	Ottawa, Ont..	Contract No. 35 of 1912. Subdivision of townships 64 and 65, range 3, and townships 63 and 64, range 4, west of the fifth meridian.
Street, P. B..	Toronto, Ont..	Subdivision in townships 11 and 12, range 2, townships 10, 11 and 12, range 3, townships 10 and 11, range 4, and townships 10, 11, 12 and 13, range 5, west of the fifth meridian. Retracement survey in townships 5, ranges 17 and 18, and township 2, range 19, west of the fourth meridian.
Stuart, A. G..	Buckingham, Que.. ..	Retracement of the principal meridian from the international boundary to the eighth base line. Resurvey of township 21, range 4, west of the principal meridian. Correction survey in townships 31, ranges 8 and 9, west of the principal meridian. Traverse of Swan lake in townships 21, ranges 5 and 6, west of the principal meridian.

APPENDIX No. 1—*Continued.*

SCHEDULE of Surveyors employed and work executed by them from April 1, 1912, to March 31, 1913—*Continued.*

Surveyor.	Address.	Description of Work.
Taggart, C. H..	Ottawa, Ont..	Subdivision in township 21, range 12, townships 21 and 25, range 13, townships 23, 24 and 25, range 14, townships 20, 21, 22, 23 and 24, range 15, townships 22 and 23, range 16, townships 17, 21 and 22, range 17, and township 18, range 18, west of the sixth meridian. Resurvey in township 21, range 13, townships 24, ranges 14 and 15, township 22, range 16, and townships 17 and 21, range 17, west of the sixth meridian. Traverse in townships 24 and 25, range 14, townships 22 and 24, range 15, township 22, range 16, and townships 17 and 21, range 17, west of the principal meridian.
Taylor, W. E..	Owen Sound, Ont.. ..	Contract No. 10 of 1912. Subdivision of townships 29, 30, 31 and 32, range 11, township 32, range 12, and the portions of townships 30 and 31, range 12, east of lake Manitoba, west of the principal meridian.
Tipper, G. A..	Brantford, Ont..	Contract No. 2 of 1912. Subdivision of townships 84 and 85 and the south two-thirds of township 82, range 2, townships 82, 83, 84 and 85, range 3, and townships 81, 82, 83 and 84, range 4, west of the sixth meridian.
Tremblay, A. J..	Edmonton, Alta..	Contract No. 33 of 1912. Subdivision of township 88 and the south two-thirds of township 89, range 8, townships 88, 89 and part of township 90, range 9, and township 88 and the south two-thirds of township 89, range 10, west of the fourth meridian.
Waddell, W. H..	Edmonton, Alta..	Contract No. 29 of 1912. Subdivision of townships 61, 62 and 63, range 18, townships 61 and 62, range 19, west of the third meridian. Survey of the east outlines of townships 64, ranges 18 and 19, west of the third meridian.
Walker, C. M..	Guelph, Ont..	Retracement survey of townships 1 and 2, range 6, west of the fourth meridian. Survey of cemetery and villa lots at Banff.
Wallace, J. N..	Calgary, Alta..	Levelling along Canadian Northern railway from Hudson Bay Junction to Islay, and also from Edmonton to Athabaska Landing and westerly along Athabaska river.

APPENDIX No. 2.

SCHEDULE showing for each surveyor employed from April 1, 1912, to March 31, 1913, the number of miles surveyed of township section lines, township outlines, traverses of lakes and rivers and resurvey, also the cost of the same.

Surveyor.	Miles of section.	Miles of outline.	Miles of traverse.	Miles of resurvey.	Total mileage.	Total cost.	Cost per mile.	Day work or contract.
						$	$ cts.	
Akins, J. R.		154		10	164	25,208	153 71	Day.
Allison, C. B.	222	24	197		443	7,888	17 81	Contract.
Aylsworth, C. F.			19	159	178	10,238	57 52	Day.
Bennett, G. A.	2		20	145	167	5,657	33 88	"
Berry, E. W.	159	44	61		264	10,300	39 02	"
Blanchet, G. H.		126			126	16,897	134 10	"
Bowman, E. P.	175	6	25		206	6,118	29 70	Contract.
Brenot, L.	170	47	52		269	19,408	72 15	Day.
Calder, J. A.	48		73	6	127	7,729	60 86	"
Campbell, A. S.			80	138	218	6,775	31 08	"
Christie, W.	200	26	194		420	8,854	21 08	Contract.
Cowper, G. C.			78	348	426	8,701	20 42	Day.
Cummings, A. L.	252	18	89		359	8,284	23 08	Contract.
Davies, T. A.	259	35	105		399	9,844	24 67	"
Day, H. S.	174	12			186	5,743	30 88	"
Evans, S. L.	17	8	45	275	345	8,645	25 06	Day.
Fairchild, C. C.	192		6		198	5,946	30 03	Contract.
Fawcett, A.	269	23	108		400	8,827	22 07	"
Francis, J.	323	6	3	36	368	9,357	25 42	"
Galletly, J. S.	278	55	74		407	18,942	46 54	Day.
Gibbon, Jas.	170	16	5		191	5,766	30 18	Contract.
Grassie, C. A.	85		71	6	162	9,610	59 32	Day.
Hawkins, A. H.		163			163	25,272	155 04	"
Herriot, G. H.		70			70	11,055	157 93	"
Jackson, J. E.	214	12	56	12	294	7,715	26 24	Contract.
Lighthall, A.	12		61	2	75	9,207	122 76	Day.
Loucks, R. W. E.	242	48	41		331	9,159	27 67	Contract.
Martindale, E. S.	58	3	11	117	189	11,140	58 94	Day.
Martyn, O. W.	176	12	7		195	5,816	29 82	Contract.
Matheson, H.	42	4	2		48	10,785	224 69	Day.
Melhuish, P.	26		55	3	84	9,213	109 68	"
Molloy, J.	268	34	159		461	10,768	23 36	Contract.
Montgomery, R. H.	230	24	58		312	8,359	26 79	"
Morrier, J. E.	230	26	72		328	8,853	26 99	"
MacLennan, A. L.	176	34	26		236	6,589	27 92	"
McEwen, D. F.	244	48	119		411	9,363	22 78	"
McFarlane, J. B.		65			65	18,632	286 64	Day.
McFarlane, W. G.	463	74	35		572	15,694	27 44	Contract.
McGrandle, H.	112	2	6		120	3,873	32 27	"
McMillan, Geo.		101			101	19,048	188 59	Day.
McNaughton, A. L.	112	22	21		155	11,466	73 97	"
Neelands, R.	200	18	11		229	6,624	28 92	Contract.
Neville, E. A.			71	8	79	7,013	88 77	Day.
Palmer, P. E.	165	21	63		249	6,206	24 92	Contract.
Pierce, J. W.	256	30	12		298	8,741	29 33	"
Plunkett, T. H.	4	273			277	33,950	122 56	Day.
Proudfoot, H. B.	111	6	20		137	3,536	25 81	Contract.
Purser, R. C.	16		19	70	105	5,397	51 40	Day.
Ransom, J. T.	102	16	76		194	4,085	21 06	Contract.
Rinfret, C.			62	567	629	7,976	12 68	Day.
Robinson, E. W.		96			96	23,165	241 30	"
Robinson, W. A.	240	32	4		276	8,563	31 03	Contract.
Rolfson, O.		199			199	19,257	96 76	Day.
Roy, J. E.,	192	30	43		265	6,775	25 56	Contract.
Saint Cyr, A.		181			181	29,991	165 69	Day.
Segre, B. H.	13			38	51	2,486	48 74	"
Seibert, F. V.	39		26	100	165	6,152	27 59	"
Soars, H. M. R.	506	112	72		690	19,971	28 94	Contract.
Starkey, S. M.	230	18	196		444	7,298	16 44	"
Steele, I. J.	253	52	158		463	10,978	23 71	"
Stewart, A. G.	471	65	56		592	17,244	29 13	"

APPENDIX No. 2—*Concluded.*

SCHEDULE showing for each surveyor employed from April 1, 1912, to March 31, 1913; the number of miles surveyed, &c.—*Concluded.*

Surveyor.	Miles of section.	Miles of outline.	Miles of traverse.	Miles of resurvey.	Total mileage.	Total cost.	Cost per mile.	Day work or contract.
						$	$ cts.	
Stewart, N. C..	89	....	52	12	153	9,320	60 91	Day.
Stewart, W. M..... .	246	30	97	....	373	7,236	19 40	Contract.
Stock, J. J..........	188	6	79	....	273	7,235	26 50	"
Street, P. B..........	76	8	8	73	165	8,915	54 03	Day.
Stuart, A. G.........	....	....	8	226	234	8,744	37 37	"
Taggart, C. H........	112	....	15	9	136	9,638	70 87	"
Taylor, W. E........	203	19	65	....	287	7.111	24 77	Contract.
Tipper, G. A........	509	62	32	....	603	17,409	28 87	"
Tremblay, A. J......	299	48	85	....	432	13,777	31 89	"
Waddell, W. H......	245	54	137	....	436	10,277	23 57	"
Walker, C. M..	....	....	8	226	234	9,848	42 09	Day.
Total............	10,365	2,718	3,509	2,586	19,178	781,662		

APPENDIX No. 3.

LIST of lots in the Yukon Territory, survey returns of which have been received from April 1, 1912, to March 31, 1913.

GROUP 2.

Lot No.	Acres.	Surveyor.	Year of Survey.	Date of Approval.	Claimant.	Remarks.
339	49·53	F. H. Kitto	1912	Dec. 6, 1912....	Otto J. Kastner...	Omenecia M. C.
347	80·9	"	1911	Dec. 6, 1912....	Malcolm McLaren........	Surface.
350	40·00	C. W. MacPherson	1912	Nov. 13, 1912.. .	A. B. Devlin.......	Surface.

GROUP 6.

Lot No.	Acres.	Surveyor.	Year of Survey.	Date of Approval.	Claimant.	Remarks.
121	51·65	H. G. Dickson....	1912	Nov. 13, 1912....	W. J. Fleming...........	Empire No. 2 M. C.
122	31·28	"	1912	Jan. 10, 1913....	"	Black Rock M. C.
123	20·08	"	1912	Jan. 10, 1913....	"	Suburban M. C.

APPENDIX No. 4.

List of miscellaneous surveys in the Yukon Territory, returns of which have been received from April 1, 1912, to March 31, 1913.

Year.	Surveyor.	Description of Survey.
1908	James Gibbon	Base line of Barker Creek, a tributary of Stewart River.
1908	"	" " 51 Pup, a tributary of Barker Creek.
1908	"	" " McRae Creek, a tributary of Barker Creek.
1908	"	" " Agate Creek, a tributary of Barker Creek.
1908	"	" " Preacher Creek, a tributary of Barker Creek.
1908	"	" " Iron Creek, a tributary of Barker Creek.
1908	"	Stewart River reference traverse from Stewart crossing to Barker Creek.
1912	F. H. Kitto.................	Base line of Scroggie Creek, a tributary of Stewart River.
1912	"	" " Walhalla Creek, a tributary of Scroggie Creek.
1912	"	" " Alberta Creek, a tributary of Scroggie Creek.
1912	"	" " Sharpe Creek, a tributary of Scroggie Creek.
1912	"	" " Mariposa Creek, a tributary of Scroggie Creek.
1912	"	" " Stevens Creek, a tributary of Scroggie Creek.
1912	"	" " Clarke Creek, a tributary of Scroggie Creek.
1912	"	Amended survey of lower part of the Sulphur Creek base line.
1912	"	Timber berth No. 143 and part of No. 119 on Klondike River.
1912	"	Tie of Astronomical Pier at Tantalus to Carmack's reference traverse.

APPENDIX No. 5.

Statement of work executed in the office of the Chief Draughtsman:—

Letters of instruction to surveyors....................	315
Progress sketches received and filed........................	1,372
Declarations of settlers received and filed..............	176
Returns of timber berths received.......................	13
Plans received from surveyors.........................	254
Field books received from surveyors................	635
Timber reports received............................	210
Observations for magnetic declination received...........	931
Miscellaneous returns received....................	168
Preliminary township plans prepared.................	334
Sketches made.............................	6,020
Maps and tracings made..........................	43[illegible]
Plans of Yukon lots received......................	6
Plans of miscellaneous Yukon surveys received..........	17
Returns of surveys examined—	
Township subdivision..........................	233
Township outline.............................	274
Road plans.............................	341
Railway plans...........................	155
Yukon lots.............................	6
Miscellaneous Yukon surveys...................	17
Mineral claims...........................	18
Timber berths...........................	25
Correction and other miscellaneous surveys..........	184

APPENDIX No. 5—*Concluded.*

STATEMENT of work executed in the office of the Chief Draughtsman—*Concluded.*

Township plans compiled	700
Townsite settlement and other plans compiled	87
Proofs of plans examined	53
Township plans printed	517
Townsite and settlement plans printed	9
Miscellaneous plans printed	153
Areas calculated	940
Pages of field notes copied	368
Applications for various information dealt with	1,727
Files received and returned	1,845
Letters and memoranda drafted	10,801
Books received from Record Office and used in connection with office work	3,632
Books returned to Record Office	4,278
Plans other than printed township plans received from Record Office and used in connection with office work	723
Plans returned to Record Office	1,104
Volumes of plans received from Record Office and used in connection with office work	86
Volumes of plans returned to Record Office	83
Books sent to Record Office to be placed on record	483
Plans other than township plans sent to Record Office to be placed on record	138
Sectional maps (3 miles to 1 inch)—	
Revised	43
Reprinted	46
Sectional maps (6 miles to 1 inch)—	
Reprinted	33

APPENDIX No. 6.

List of new editions of Sectional Maps issued from April 1, 1912, to March 31, 1913.

Scale—3 miles to one inch.

No.	Name.	No.	Name.	No.	Name.	No.	Name.
14	Pincer Creek........	111	Kamloops	215	Red Deer........	316	Vermilion.
16	Milk River.....	112	Sicamous...........	217	Tramping Lake.....	317	Fort Pitt.
17	Cypress....	114	Calgary	218	Saskatoon..........	364	Fort Assiniboine.
19	Willowbunch	115	Blackfoot..........	219	Humboldt	365	Victoria.
20	Souris......	116	Rainy Hills.........	222	Waterhen	366	Saddle Lake.
22	Dufferin.	117	Red Deer Forks	262	Yellowhead.........	367	Meadow Lake.
24	Lake of the Woods..	118	Rush Lake	263	Jasper........	368	Green Lake.
64	Porcupine...........	161	Morley	264	Brazeau.	412	Wapiti.
66	Medicine Hat	166	Sounding Creek.....	265	Peace Hills.........	416	La Biche.
67	Maple Creek	167	Bad Hills........ .	267	Battleford..........	461	Giroux.
69	Moosejaw......	168	The Elbow..........	268	Carlton	513	Heart River.
70	Moose Mountain....	169	Touchwood	314	St. Ann.		
74	Cross Lake..... ...	171	Duck Mountain.....	315	Edmonton.		

Scale—6 miles to one inch.

16	Milk River.........	74	Cross Lake..........	213	Athabaska..........	315	Edmonton.
17	Cypress.	111	Kamloops	217	Tramping Lake.....	316	Vermilion.
19	Willowbunch........	112	Sicamous...........	218	Saskatoon	317	Fort Pitt.
20	Souris................	116	Rainy Hills....... .	222	Waterhen	366	Saddle Lake.
22	Dufferin	117	Red Deer Forks....	264	Brazeau.............	412	Wapiti.
24	Lake of the Woods..	165	Rosebud	266	Ribstone Creek......	462	Dunvegan.
64	Porcupine...........	167	Bad Hills.	268	Carlton.		
67	Maple Creek	169	Touchwood	313	Brulé.		

APPENDIX No. 7.

STATEMENT of work executed in the Photographic office from April 1, 1912, to March 31, 1913.

—	3¼ x 3¼	3¼ x 5½	5 x 7	8 x 10	10 x 12	11 x 14	15 x 18	16 x 18	18 x 20	20 x 24	24 x 30	24 x 32	24 x 35	30 x 36	32 x 49	36 x 42	42 x 48	Total.
Dry plates and films	12	659	625	17	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,328
Bromide prints	.....	2	12	104	14	353	.....	105	25	112	77	.....	.....	92	.....	43	17	956
Solio prints	.....	31	361	344	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	739
Velox prints	.....	5,874	4,387	19	.....	78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10,358
Artura prints	.....	.....	.....	62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	62
Vandyke prints	.....	.....	9	6	84	3	.....	31	73	94	246	.....	.....	235	.....	166	16	963
Blue prints	.....	.....	14	53	36	60	.....	277	158	130	168	.....	.....	307	.....	110	29	1,342
Lantern transparencies	181	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	181
Photographs mounted	.....	18	36	34	.....	8	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	97
Wet plate negatives	.....	.....	.....	99	.....	228	744	.....	170	79	.....	55	.....	.....	.....	.....	.....	1,375
Photo-litho plates	.....	.....	.....	.....	.....	.....	.....	.....	155	52	.....	.....	126	.....	194	.....	.....	527
Total	193	6,584	5,444	738	135	747	744	414	581	467	491	55	126	634	194	319	62	17,928

APPENDIX No. 8.

STATEMENT of work executed in the Lithographic Office from April 1, 1912, to March 31, 1913.

Month.	Maps.			Township Plans.			Forms.		
	No.	Copies.	Impressions.	No.	Copies.	Impressions.	No.	Copies.	Impressions.
1912.									
April........	11	7,675	19,675	22	4,400	5,000	1	200	400
May..............	11	5,000	14,975	55	11,000	11,200	6	8,287	8,587
June..............	20	13,900	28,900	70	14,000	14,400	1	2,000	2,000
July............. .	10	9,375	25,225	17	3,400	4,000	2	950	1,400
August......	27	12,850	13,225	30	6,000	6,600	1	1,000	1,000
September.........	15	6,900	6,900	89	17,800	18,600	1	700	700
October...........	14	6,190	6,190	9	1,800	2,200	3	4,000	4,000
November.........	2	325	325	11	2,200	2,200	1	600	600
December.........	5	2,500	2,500	42	8,400	8,400	2	1,013	1,013
1913.									
January...........	11	32,215	135,045	73	14,600	14,800	5	21,000	23,000
February..........	6	2,725	2,725	40	8,000	8,000	6	9,500	9,500
March............	9	2,000	2,500	93	18,600	19,000	3	5,300	5,400
Total.........	141	101,655	258,185	551	110,200	114,400	32	54,550	57,600

RECAPITULATION.

—	No.	Copies.	Impressions.	Cost.
				$
Maps......	141	101,655	258,185	2,706 66
Township plans..............	551	110,200	114,400	4,088 00
Forms..	32	54,550	57,600	617 34
Grand total...........	724	266,405	430,185	7,412 00

List of employees of the Topographical Surveys Branch at Ottawa, giving the name, classification, duties of office and salary of each. (Metcalfe street, corner of Slater.)

Name.	Classification.		Duties of Office.	Salary.
	Division.	Sub-division.		
				$
Deville, E., D.T.S., LL.D	1	A	Surveyor General	3,750
	Correspondence.			
Brady, M	1	B	Secretary	2,500
Cullen, M. J	3	A	Stenographer	1,200
Moran, J. F	3	A	Clerk	950
Williams, E. R	3	A	Correspondence clerk	950
Addison, W. G	3	B	Typewriter	800
Renault, J. F	3	B	"	700
Pegg, A			Messenger	800
O'Meara, M. T			"	600
	Accounts.			
Hunter, R. H	2	A	Accountant	2,100
Lemay, A	2	A	Asst. Accountant	1,600
Wilkinson, Percy	3	A	"	1,150

Chief Draughtsman's Office (Metcalfe street, corner of Slater)—General Direction and Supervision of the Technical Work.

Shanks, T., B.A.Sc., D.L.S	1	B	Chief draughtsman	2,650
Brown, T. E., B.A	1	B	Asst. chief draughtsman	2,650

Chief Draughtsman's Office, First Section (Metcalfe street, corner of Slater)—Survey instructions and general information.

Barber, H. G., Grad. S.P.S	2	A	Chief of section	1,950
Rice, F. W., Grad. School of Mining	2	A	Asst. chief of section	1,950
MacIlquham, W. L., B.Sc	2	A	" "	1,950
Weld, W. E	2	A	" "	1,950
Peaker, W. J., Grad. S.P.S	2	A	" "	1,650
Carroll, M. J., Grad. S.P.S	2	A	" "	1,600
Rochon, E. C	2	A	" "	1,600
McRae, A. D., B.A., B.Sc	2	B	Draughtsman	1,450
Grant, A. W., B.A	2	B	"	1,450
Hayward, H. E., B.Sc	2	B	"	1,350
MacMillan, J. P., B.E	2	B	"	1,350
Wadlin, L. N., B.Sc	2	B	"	1,250
Cordukes, J. P., B.Sc	2	B	"	1,250
Gagnon, J. N. H., B.A.S	2	B	"	1,100
Armstrong, W. B., B.Sc	2	B	"	1,250
Nevins, L. A., B.A	2	B	"	1,250
McDonald, J. F., B.A	2	B	"	1,250
Sammon, J. J., B.A	2	B	"	1,200
Fleming, A. C., B.A	2	B	"	1,200
Kydd, Geo., B.Sc	2	B	"	1,200
Quinlan, L. J., B.A.Sc	2	B	"	1,200
Mills, T. S., B.A., B.Sc	2	B	"	1,200
Holbrook, C. H	3	A	Clerk	1,000
Burkholder, E. L	3	A	"	950

Chief Draughtsman's Office, Second Section (Metcalfe street, corner of Slater)—Surveys in Manitoba, Saskatchewan, Alberta and Yukon Territory.

Name.	Classification.		Duties of Office.	Salary.
	Division.	Sub-division.		
				$
Nash, T. S., Grad. S.P.S., D.L.S.	1	B	Chief of section	2,650
Dennis, E. M., B. Sc	2	A	Asst. chief of section	1,950
Elder, A. J., Grad. S.P.S., D.L.S.	2	A	" "	1,950
Hill, S. N., Grad S.P.S.	2	A	" "	1,950
Genest, P. F. X., Q.L.S.	2	A	" "	1,950
Kitto, F. H., D.L.S.	2	A	In charge of Dawson office	1,650
Sutherland, H. E., B.Sc.	2	A	Asst. chief of section	1,600
McClennan, W. D.	2	A	" "	1,600
Roger, A., O.L.S.	2	A	" "	1,600
Spreckley, R. O.	2	B	Draughtsman	1,550
Goodday, Leonard	2	B	"	1,450
Bray, R. P.	2	B	"	1,450
Harrison, E. W.	2	B	"	1,350
Ault, H. W.	2	B	"	1,350
Lytle, W. J.	2	B	"	1,100
LaBeree, E. E.	2	B	"	1,100
Jones, G. S., Grad. S.P S., O.L.S.	2	B	"	1,100
Bradley, J. D.	2	B	"	1,100
Fournier, O. E., B.A.S.	2	B	"	1,100
Thomas, A. S., B.Sc.	2	B	"	1,250
Kirwan, A. L., B.A.Sc.	2	B	"	1,200
Robinson, S. D., B.Sc.	2	B	"	1,200
Macdonald, J. A.	3	B	Clerk	800

Chief Draughtsman's Office, Third Section—(Imperial Building, Queen street). Copying plans for reproduction.

Engler, Carl., B. A., D.L.S.	1	B	Chief of section	2,200
May, J. E.	2	A	Asst. chief of section	1,950
O'Connell, J. R.	2	A	" "	1,750
Moule, W. J	2	B	Draughtsman	1.600
Helmer, J. D.	2	B	"	1,150
Dawson, R. J	2	B	"	1,150
Archambault, E.	2	B	"	1,150
Clarke, G, N	2	B	"	800
Watters, James	3	A	Printer	1,200
McLennan, A. G.	3	A	Clerk	1,200
Brown, A.	3	A	"	950
Ebbs, E. J.	3	A	"	950
Baril, C.	3	B	Draughtsman	800

Chief Draughtsman's Office, Fourth Section—(Imperial Building, Queen street). British Columbia surveys.

Rowan-Legg, E. L.	2	A	Chief of section	2,100
Gillmore, E. T B., Grad, R.M.C.	2	A	Asst. chief of section	2,050
Morley' R. W.	2	A	" "	1,950
Wilson, E. E. D., B. Sc.	2	A	" "	1,650
Harris, K. D.	2	B	Draughtsman	1,350

Chief Draughtsman's Office, Fifth Section—(Imperial Building, Queen street). Mapping.

Name.	Classification. Division.	Sub-division.	Duties of Office.	Salary
				$
Smith, J	1	B	Chief of section	2,650
Begin, P. A	2	A	Asst. chief of section	2,000
Blanchet, A. E	2	A	" "	1,600
Côté, J. A., Grad. R.M.C	2	A	" "	1,650
D'Orsonnens, A	2	A	" "	1,600
Flindt, A. H	2	A	" "	1,750
Bergin, W	2	B	Draughtsman	1,150
Blanchard, J. F	2	B	"	1,100
Brigly, J. H	2	B	"	1,350
Colquhoun, G. A., B. Sc	2	B	"	1,250
Davies. T. E. S	2	B	"	1 600
Davy, E	2	B	"	1,450
Freeland, J. J., M.A	2	B	"	1.250
Howie, Jas	2	B	"	1,050
Perrin, V	2	B	"	1,600
Purdy, W. A	2	B	"	1,150
Villeneuve, E	2	B	"	1,150

Chief Draughtsman's Office, Sixth Section—(Imperial Building, Queen street). Scientific and topographical work.

Dodge, G. B., D.L.S	1	B	Chief of section	2,650
Watt. G. H., Grad. S.P.S., D.L.S	2	A	Asst. chief of section	1,950
Cannell, H. W	2	B	Draughtsman	1,200
Chartrand, D. E., B.Sc	2	B	"	1,150
Cousineau, A., B.Sc	2	B	"	1,150
Dozois, L. O. R., Grad. R.M.C	2	B	"	1,150
Herbert, W. H., B.Sc	2	B	"	1,250
Hill, Jas., M.A., B.Sc	2	B	"	1,200
Hughson, W. G., B.Sc	2	B	"	1,200
Milliken, J, B., B.A., B.Sc., D.L.S	2	B	"	1,350
Parry, H., B.Sc., D.L.S	2	B	"	1,050
Roe, B. J	2	B	"	1,200
Ross, R. C., B.Sc	2	B	"	1,250
Way. W. C., M.Sc	2	B	"	1,200
Lynch, F. J	3	B	Typewriter	800
Watson, J. W	3	B	Clerk	800
Pick, A. C	....	... .	Messenger	550

Geographic Board (Woods Building, Slater street).

Whitcher, A. H., F.R.G.S., D.L.S	2	A	Secretary	2,100

Photographic Office (Metcalfe street, corner Slater street).

Carruthers, H. K	2	A	Process photographer	1,950
Woodruff, John	2	A	Chief "	1,950
Smith, L. G	2	B	Photographer	850
Whitcomb, H. E	3	A	"	1,200
Morgan, W. E	3	A	"	1,200
Kilmartin, A	3	A	Asst. photographer	950
Devlin, A	3	B	"	800
Ouimet. E. G	3	B	"	800

Lithographic Office (unclassified) (Imperial Building, Queen street).

Name.	Occupation.	Salaries.
Moody, A.	Foreman	$27 00 per week.
Burnett, E.	Lithographer	25 00 "
Thicke, C. R.	"	23 00 "
Deslauriers, J. H.	Transferrer	20 00 "
Bergin, J.	Printer	21 00 "
Thicke, H. S.	"	20 00 "
Boyle, S.	Stone polisher	15 00 "
Gagnon, J.	Press feeder	12 00 "
Kane, P.	"	9 50 "
Easton, R. M.	Printer	19 50 "
Hare, E. H.	Asst. photographer	15 00 "

Chief Inspector of Surveys Office (98 Wellington street).

Name.	Classification.		Duties of Office.	Salaries.
	Division.	Sub-division.		
				$
Hubbell, E. W., D.L.S.	1	B	Chief inspector	2,800
Sylvain, John	2	A	Assistant	1,700
Stalker, Miss M. W.	3	A	Clerk	950

Board of Examiners for D.L.S.

F. D. Henderson, Grad. S.P.S.	2	A	Secretary	1,950

APPENDIX No. 10.

List of Dominion Land Surveyors who are in possession of Standard Measures.

Name.	Address.	Date of Birth.	Date of Appointment or of Commission.	Remarks.
Akins, James Robert	Ottawa, Ont	Sept. 2, '76	Mar. 14, '10	
Allison, Calvin Bruce	South Woodslee, Ont.	June 16, '84	Mar. 28, '10	O.L.S.
Ashton, Arthur Ward	Ottawa, Ont	Nov. 5, '80	May 29, '08	B.C.L.S.
Austin, George Frederick	Not known	....	April 14, '72	
Aylen, John	North Bay, Ont	....	May 29, '85	
Aylsworth, Charles Fraser	Madoc, Ont	April 21, '62	May 13, '86	O.L.S.
Baker, James Clarence	Vermilion, Alta	May 12, '78	May 18, '06	A.L.S.
Baker, Mason Hermon	St. Thomas, Ont	July 9, '84	Aug. 6, '08	O.L.S.
Bartlett, Ernest	Medicine Hat, Alta.	—— '83	Jan. 16, '11	A.L.S.
Bayne, George A	Winnipeg, Man	Oct. 25, '50	April 14, '72	M.L.S.
Beatty, David	Parry Sound, Ont	Dec. 22, '42	April 14, '72	O.L.S.
Begg, William Arthur	Hamilton, Ont	July 15, '82	June 8, '09	S L.S.
Belanger, Phidime Roch Arthur	Ottawa, Ont	Mar. 5, '53	May 17, '80	Inspector of Surveys, Topographical Surveys Branch, Dept. of the Interior.
Belleau, Joseph Alphonse	Ottawa, Ont	Sept. 30, '56	May 15, '83	Land Patents Branch, Department of Interior.
Belyea, Albert Palmer Corey	Edmonton, Alta	....	July 14, '09	A.L.S.
Bemister, George Bartlett	Winnipeg, Man	....	June 11, '78	M.L.S. Engineering Dept. C.N.R.
Bennett, George Arthur	Calgary, Alta	May 18, '86	Aug. 25, '10	A.L.S.
Berry, Edward Wilson	Seaforth, Ont	Aug. 26, '81	May 18, '11	
Bigger, Charles Albert	Ottawa, Ont	Aug. 15, '53	Mar. 30, '82	B.C.L.S., O.L.S., Assistant Superintendent Geodetic Survey.
Bingham, Edwin Ralph	Fort William, Ont	—— '78	Oct. 25, '06	O.L.S.
Blanchet, Guy Houghton	Ottawa, Ont	Feb. 12, '84	Mar. 10, '10	
Boswell, Elias John	Montreal, Que	....	Mar. 18, '03	O.L.S., M.L.S.
Bourgeault, Armand	St. Jean Port Joli, Que	Feb. 23, '58	Mar. 29, '83	Q.L.S.
Bourgault, Charles Eugene	Lauzon, Levis, Que	Sept. 6, '61	Feb. 21, '88	
Bourget, Charles Arthur	Lauzon, Que	Aug. 26, '51	May 14, '84	Q.L.S.
Bowman, Edgar Peterson	West Montrose, Ont.	Sept. 29, '83	Sept. 26, '07	O.L.S.
Bowman, Herbert Joseph	Berlin, Ont	June 18, '65	Feb. 16, '88	O.L.S.
Brabazon, Alfred James	Ottawa, Ont	....	May 13, '82	Boundary Survey, Dept. of the Interior.
Brady, James	Golden, B.C	Nov. 24, '40	April 14, '72	O.L.S., B.C.L.S.
Bray, Samuel	Ottawa, Ont	Nov. 5, '46	Nov. 14, '83	O.L.S., Chief Surveyor, Dept. of Indian Affairs.
Bray, Lennox Thomas	Edmonton, Alta	Mar. 14, '77	Feb. 18, '03	O.L.S., A.L.S.
Brenot, Lucien	Ottawa, Ont	Aug. 31, '87	Mar. 18, '10	
Bridgland, Morrison Parsons	Calgary, Alta	Dec. 20, '78	Mar. 10, '05	A.L.S.
Broughton, George Henry	Penticton, B.C	Aug. 12, '86	June 3, '09	B.C.L.S.
Brown, Charles Dudley	Winnipeg, Man	Feb. 25, '83	April 4, '10	A.L.S., S.L.S.
Brown, Edgar Carl	Regina, Sask	Nov. 28, '86	May 23, '11	A.L.S., S.L.S.
Brown, Thomas Wood	Regina, Sask	....	June 21, '09	A.L.S., S.L.S.
Brownlee, James Harrison	Vancouver, B.C	Mar. 22, '56	April 15, '87	M.L.S., B.C.L.S.
Buchanan, John Alexander	Edmonton, Alta	Mar. 4, '87	May 17, '12	A.L.S.
Burd, James Henry	Weyburn, Sask	Sept. 7, '71	May 18, '11	O.L.S., S.L.S.
Burgess, Edward LeRoy	Victoria, B.C	May 5, '78	Feb. 23, '05	O.L.S.
Burnet, Hugh	Victoria, B.C	....	June 22, '85	O.L.S., B.C.L.S.
Burwash, Nathaniel Alfred	Whitehorse, Y.T	Sept. 28, '79	Mar. 6, '07	O.L.S.
Burwell, Herbert Mahlon	Vancouver, B.C	Oct. 23, '63	Feb. 17, '87	B.C.L.S.
Calder, John Alexander	Lytton, B.C	June 2, '86	May 21, '12	
Campbell, Alan John	Sidney, B.C	Oct. 1, '82	April 13, '09	B.C.L.S., A.L.S.
Campbell, Alexander Stewart	Kingston, Ont	Mar. 7, '80	Mar. 6, '09	O.L S.
Carbert, Joseph Alfred	Medicine Hat, Alta	Feb. 4, '56	May 12, '80	O.L.S., A.L.S., District Engineer and Surveyor, Dept. of Public Works, Alberta.
Carpenter Henry Stanley	Regina, Sask	Feb. 8, '74	Feb. 20, '01	O.L.S., S.L.S., Department of Public Works.
Carroll, Cyrus	Regina, Sask	Dec. 6, '34	April 14, '72	O.L.S., S.L.S.

APPENDIX No. 10—*Continued.*

List of Dominion Land Surveyors who are in possession of Standard Measures.—*Continued.*

Name.	Address.	Date of Birth.	Date of Appointment or of Commission.	Remarks.
Carson, Percy Alexander	Kamloops, B.C	Dec. 25, '77	Feb. 22, '06	Hydrographic Survey.
Carthew, William Morden	Edmonton, Alta	Oct. 19, '86	Mar. 29, '10	A.L.S.
Carthew, John Trewalla	Edmonton, Alta	Feb. 15, '91	Mar. 15, '13	
Cautley, Reginald Hutton	Edmonton, Alta	Dec. 6, '79	May 1, '05	A.L.S.
Cautley, Richard William	Edmonton, Alta	Aug. 3, '73	Sept. 2, '96	A.L.S.
Cavana, Allan George	Orillia, Ont	Jan. 22, '58	Nov. 16, '76	O.L.S.
Charlesworth, Lionel Clare	Edmonton, Alta	Nov. 17, '73	Mar. 24, '03	O.L.S., A.L.S., Dept. of Pub. Works, Alberta.
Chase, Albert Victor	Orillia, Ont	Mar. 4, '83	Oct. 11, '10	O.L.S.
Chilver, Charles Alonzo	Walkerville, Ont	Feb. 8, '83	Feb. 22, '07	
Christie, William	Prince Albert, Sask.	Feb. 13, '76	Mar. 22, '06	S.L.S.
Clarke, Charles Wentworth	Regina, Sask	Nov. 19, '75	Mar. 21, '10	S.L.S.
Cleveland, Ernest Albert	Vancouver, B.C	May 12, '74	June 27, '99	B.C.L.S.
Coates, Preston Charles	Victoria, B.C	May 16, '81	April 19, '07	B.C.L.S.
Cokely, Leroy S	Duncan, B.C	Nov. 23, '84	Mar. 22, '10	B.C.L.S.
Cond, Fritz Thomas Piercy	Vancouver, B.C	May 16, '86	May 18, '11	B.C.L.S.
Côté, Joseph Adélard	Prince Albert, Sask.	June 5, '64	May 14, '84	S.L.S.
Côté, Jean Léon	Edmonton, Alta	May 6, '67	Mar. 21, '90	A.L.S.
Cotton, Arthur Frederick	Massett, B.C	Aug. 8, '52	May 11, '80	O.L.S., B.C.L.S.
Cowper, George Constable	Welland, Ont	Oct. 20, '86	Mar. 11, '11	
Craig, John Davidson	Ottawa, Ont	Jan. 30, '76	Feb. 24, '02	Boundary Surveys, Dept. of the Interior.
Cumming, Austin Lewis	Edmonton, Alta	Aug. 25, '82	Feb. 3, '10	A.L.S.
Cummings, Alfred	Fernie, B.C	July 3, '80	Mar. 3, '09	B.C.L.S.
Cummings, John George	Cranbrook, B.C	Nov. 19, '73	Feb. 17, '04	B.C.L.S.
Dalton, John Joseph	Weston, Ont	June 12, '54	Apr. 17, '79	O.L.S., D.T.S.
Davies, Thomas Attwood	Edmonton, Alta	....	Feb. 22, '06	A.L.S.
Dawson, Frederick James	Kamloops, B.C	Sept. 22, '86	Sept. 12, '10	B.C.L.S.
Day, Harry Samuel	Edmonton, Alta	Nov. 14, '85	Mar. 9, '10	A.L.S.
Deans, William James	Brandon, Man	May 4, '60	May 13, '86	O.L.S.
de la Condamine, C	Calgary, Alta	Feb. 13, '75	May 4, '10	A.L.S.
Dennis, John Stoughton	Calgary, Alta	Oct. 22, '56	Nov. 19, '77	D.T.S.
Denny, Herbert C	Not known	....	Apr. 1, '82	
Dickson, Henry Godkin	Whitehorse, Y.T	Mar. 29, '64	Mar. 19, '89	M.L.S.
Dickson, James	Fenelon Falls, Ont	Oct. 30, '34	Apr. 14, '72	O.L.S.
Dobie, James Samuel	Thessalon, Ont	Oct. 15, '73	Mar. 22, '06	O.L.S.
Donnelly, Cecil	Winnipeg, Man	Oct. 18, '89	Mar. 15, '13	
Doupe, Jacob Lonsdale	Winnipeg, Man	Sept. 14, '67	Oct. 6, '88	M.L.S., A.L.S., S.L.S., Asst. Land Commissioner for C.P.R.
Drewry, William Stewart	Victoria, B.C	Jan. 20, '59	Nov. 14, '83	O.L.S., B.C.L.S.
Driscoll, Alfred	Edmonton, Alta	July 2, '65	Feb. 23, '87	B.C.L.S., A.L.S.
Drummond, Thomas	Montreal, P.Q	1856	June 24, '78	D.T.S.
Ducker, William A.	Winnipeg, Man	April 4, '52	Mar. 30, '83	O.L.S., M.L.S.
Dumais, Paul T. Concorde	Hull, P.Q	Jan. 2, '47	Mar. 29, '82	Q.L.S.
Earle, Wallace Sinclair	Victoria, B.C	Feb. 8, '89	May 18, '11	B.C.L.S., O.L.S.
Edwards, George	Ponoka, Alta	June 13, '42	Apr. 14, '72	O.L.S., A.L.S.
Edwards, William Milton	Lethbridge, Alta	June 21, '79	Apr. 5, '10	A.L.S.
Ellacott, Charles Herbert	Victoria, B.C	Dec. 24, '66	Feb. 22, '99	B.C.L.S.
Ellis, Douglas Stewart	Kingston, Ont	Mar. 16, '85	May 17, '12	
Empey, John Morgan	Calgary, Alta	Apr. 16, '74	Feb. 23, '05	O.L.S., A.L.S.
Engler, Carl	Ottawa, Ont	Sept. 30, '72	Feb. 23, '05	T. S. Branch, Dept. of Interior.
Evans, Stanley Livingstone	Corinth, Ont	Jan. 14, '84	Feb. 13, '11	
Fairchild, Charles Courtland	Edmonton, Alta	Feb. 21, '67	Feb. 20, '01	O.L.S., A.L.S.
Farncomb, Alfred Ernest	Edmonton, Alta	May 22, '73	Mar. 12, '02	O.L.S., A.L.S.
Fawcett, Thomas	Ottawa, Ont	Oct. 28, '48	Nov. 18, '76	O.L.S., D.T.S., Boundary Surveys, Dept. of Interior.
Fawcett, Adam	Gravenhurst, Ont	....	Feb. 22, '93	
Ferguson, George Hendry	Toronto, Ont	Jan. 20, '83	June 2, '09	
Findlay, Allan	Winnipeg, Man	Oct. 15, '80	Mar. 21, '08	M.L.S.
Fletcher, James Allan	Fletcher, Ont	Mar. 26, '89	May 18, '11	

APPENDIX No. 10—*Continued.*

List of Dominion Land Surveyors who are in possession of Standard Measures—*Continued.*

Name.	Address.	Date of Birth.	Date of Appointment or of Commission.	Remarks.
Fontaine, Louis Elie	Levis, P.Q	Oct. 3, '68	Nov. 30, '92	A.L.S., Inspector of Surveys, Dept. of Interior.
Francis, John	Portage la Prairie, M	Dec. 22, '52	June 17, '75	M.L.S.
Galletly, James Simpson	Brooklin, Ont.	Apr. 15, '88	May 18, '11	
Garden, James Ford	Vancouver, B.C.	Feb. 19, '47	May 13, '80	B.C.L.S.
Garden, George H.	Lethbridge, Alta.	....	Apr. 14, '72	Deputy Surveyor for N.B
Garden, Charles	Not known	....	Apr. 14, '72	Deputy Surveyor for N.B.
Garner, Albert Coleman	Regina, Sask.	Sept. 6, '78	May 27, '07	S.L.S., A.L.S., Chief Surveyor Surveys Branch Land Titles Offices.
Gauvreau, Louis Pierre	Not known	....	Apr. 14, '72	
Gibbon, James	Vancouver, B.C.	June 25, '60	Feb. 12, '91	O.L.S.
Glover, Arthur Edward	Edmonton, Alta.	Mar. 4, 87	Mar. 11, '11	A.L.S., S.L.S.
Gordon, Maitland Lockhart	Vancouver, B.C.	Sept. 27, '82	Feb. 18, '04	B.C.L.S.
Gordon, Robert John	Lethbridge, Alta.	June 18, '69	Mar. 12, '02	A.L.S.
Gore, Thomas Sinclair	Victoria, B.C.	1852	Apr. 19, '79	B.C.L.S.
Graham, John Robertson	Vancouver, B.C.	Apr. 18, '87	May 26, '10	B.C.L.S.
Grassie, Charles Andrew	Medicine Hat, Alta.	Dec. 24, '83	Dec. 27, '10	A.L.S.
Gray, James Edward	Edmonton, Alta.	Oct. 12, '81	Mar. 11, '11	A.L.S., S.L.S.
Green, Alfred Harold	Nelson, B.C.	Jan. 20, '79	Feb. 23, '05	B.C.L.S., A.L.S.
Green, Thomas Daniel	Ottawa, Ont.	Dec. 21, '57	May 19, '84	O.L.S.
Green, Frank Compton	Victoria, B.C.	....	May 8, '03	B.C.L.S.
Grover, George Alexander	Toronto, Ont.	....	Feb. 18, '04	
Haggen, Rupert Williams	Quesnel, B.C.	July 29, '87	May 18, '11	B.C.L.S.
Hamilton, Charles Thomas	Vancouver, B.C.	July 29, '84	May 18, '11	B.C.L.S.
Hamilton, James Frederick	Lethbridge, Alta.	April 4, '69	June 2, '09	A.L.S.
Harris, John Walter	Winnipeg, Man.	Feb. 26, '45	April 14, '72	O.L.S., M.L.S., Assessment Commissioner and City Surveyor.
Harrison, Edward	Calgary, Alta.	....	May 14, '10	A.L.S.
Harvey, Charles	Kelowna, B.C.	May 5, '76	Feb. 17, '04	B.C.L.S.
Hawkins, Albert Howard	Listowel, Ont.	July 27, '62	Mar. 6, '06	
Heaman, John Andrew	Winnipeg, Man.	June 3, '75	July 15, '09	O.L.S.
Heathcott, Robert Vernon	Edmonton, Alta.	July 7, '81	May 13, '07	A.L.S.
Henderson, Walter	Not known	....	Nov. 17, '83	
Herriot, George Henry	Souris, Man.	Feb. 23, '83	Sept. 18, '09	
Heuperman, Frederick Justinus	Calgary, Alta.	July 23, '87	Mar. 13, '11	A.L.S.
Heuperman, Lambertus Fred.	Calgary, Alta.	Sept. 20, '81	Mar. 29, '10	A.L.S.
Hoar, Charles Millard	Calgary, Alta.	Sept. 26, '85	Mar. 9, '11	A.L.S.
Hobbs, Wilfrid Ernest	Winnipeg, Man.	Mar. 12, '87	Mar. 5, '12	M.L.S.
Holcroft, Herbert Spencer	Toronto, Ont.	Sept. 4, '77	Feb. 18, '03	O.L.S.
Hopkins, Marshall Willard	Edmonton, Alta.	May 24, '61	Feb. 20, '01	O.L.S., A.L.S.
Hubbell, Ernest Wilson	Ottawa, Ont.	Nov. 5, '62	May 19, '84	Chief Inspector of Surveys, Dept. of Interior.
Inkster, Oluff	Edmonton, Alta.	Mar. 25, '85	May 18, '11	A.L.S.
Jackson, John Edwin	Hamilton, Ont.	Dec. 27, '81	May 18, '11	O.L.S.
James, Silas	Toronto, Ont.	June 19, '34	April 14, '72	O.L.S.
Jephson, Richard Jermy	Brandon, Man.	Feb. 5, '54	May 12, '80	O.L.S., B.C.L.S., M.L.S
Johnson, Alfred William	Kamloops, B.C.	Feb. 23, '74	Mar. 12, '02	B.C.L.S.
Johnston, James Homer	Edmonton, Alta.	Aug. 23, '87	May 17, '12	A.L.S.
Keith, Homer Pasha	Edmonton, Alta.	Aug. 30, '85	Feb. 1, '11	A.L.S.
Kimpe, Maurice	Edmonton, Alta.	Jan. 17, '76	May 13, '07	A.L.S.
King, William Frederick	Dominion Observatory, Ottawa, Ont.	Feb. 19, '54	Nov. 21, '76	D.T.S. Chief Astronomer Dept. of Interior.
Kirk, John Albert	Summerland, B.C.	Jan. 9, '54	May 11, '80	O.L.S., B.C.L.S.
Kitto, Franklin Hugo	Dawson, Y.T.	Mar. 28, '80	Mar. 6, '08	
Klotz, Otto Julius	Dominion Observatory, Ottawa, Ont.	Mar. 31, '52	Nov. 19, '77	O.L.S., D.T.S., Astronomer, Dept. of Interior.
Knight, Richard H.	Edmonton, Alta.	June 7, '77	Feb. 18, '04	A.L.S.
Lamb, Frederick Carlyle	Saskatoon, Sask.	Dec. 11, '88	May 17, '12	
Lang, John Leiper	Sault Ste. Marie, Ont	....	Oct. 14, '08	O.L.S.
Latimer, Frank Herbert	Penticton, B.C.	May 23, '60	Nov. 13, '85	B.C.L.S.

APPENDIX No. 10—*Continued.*

List of Dominion Land Surveyors who are in possession of Standard Measures—*Continued.*

Name.	Address.	Date of Birth.	Date of Appointment or of Commission.	Remarks.
Laurie, Richard C	Battleford, Sask	Jan. 31, '58	April 27, '83	S.L.S.
Lemoine, Charles Errol	Ville Montcalm, P.Q.	....	Mar. 31, '82	Q.L.S.
Lighthall, Abram	Vancouver, B.C.	Mar. 30, '78	Dec. 25, '09	
Lindsay, James Herbert	Prince Albert, Sask.	Nov. 27, '82	May 18, '11	S.L.S.
Lonergan, Gerald Joseph	Buckingham, P.Q.	Oct, 8, '71	Feb. 28, '01	Q.L.S., A.L.S., Inspector of Surveys, Dept. of Interior.
Loucks, Roy Wm. Egbert	Saskatoon, Sask	Oct. 31, '84	Mar. 1, '12	A.L.S., S.L.S.
Lumsden, Hugh David	Ottawa, Ont	Sept. 7, '44	April 14, '72	O.L.S.
MacLennan, Alexander L	Toronto, Ont	May 10, '78	Feb. 23, '05	S.L.S.
MacLeod, George Waters	Edmonton, Alta	—— '88	Mar. 1, '12	A.L.S.
MacPherson, Charles Wilfrid	Dawson, Y.T	Sept. 6, '71	Mar. 7, '00	O.L.S.
Macdonald, Gordon Alexander	Muirkirk, Ont	May 24, '85	May 17, '12	
Magrath, Charles Alexander	Ottawa, Ont	April 22, '60	Nov. 16, '81	B.A.Sc., O.L.S., B.C.L.S. D.T.S., Member International Waterways Commission.
Martindale, Ernest Smith	Kingsmill, Ont.	May 20, '86	Mar. 11, '11	
Martyn, Oscar William	Regina, Sask	Dec. 2, '88	Mar. 11, '11	S.L.S.
Matheson, Hugh	Ottawa, Ont	May 2, '79	May 9, '11	
Meadows, William Walter	Maple Creek. Sask	May 27, '73	Feb. 23, '05	O.L.S., S.L.S.
Melhuish, Paul	Vancouver, B.C	April 11, '87	May 18, '11	B.C.L.S.
Miles, Charles Falconer	Toronto, Ont.	Jan. 30, '38	April 14, '72	O.L.S. Inspector of Surveys, Dept. of Interior.
Mitchell, Benjamin Foster	Edmonton, Alta	June 16, '80	April 16, '08	A.L.S.
Moberly, Harford Kenneth	Moosomin, Sask	———, '69	April 21, '03	S.L.S.
Molloy, John	Winnipeg, Man	Jan. 13, '40	April 14, '72	M.L.S.
Montgomery, Royal Harp	Prince Albert, Sask	May 20, '82	Feb. 23, '05	O.L.S., S.L.S.
Moore, Herbert Harrison	Calgary, Alta	Dec. 1, '69	Feb. 17, '04	A.L.S.
Morrier, Joseph Eldedge	Prince Albert, Sask.	Aug. 29, '74	May 16, '07	S.L.S.
Murray, Ernest William	Regina, Sask	Mar. 20, '84	May 31, '10	S.L.S.
McArthur, James Joseph	Ottawa, Ont	May 9, '56	April 17, '79	Boundary Surveys, Dept. of Interior.
McCaw, Robert Daniel	Sidney, B.C	May 24, '83	Mar. 23, '09	O.L.S., B.C.L.S., A.L.S.
McColl, Gilbert Beebe	Winnipeg, Man	Oct. 8, '82	Mar. 20, '07	M.L.S., D.T.S.
McColl, Samuel Ebenezer	Winnipeg, Man	July 17, '86	May 18, '11	M.L.S.
McDiarmid, Stuart Stanley	Vancouver, B.C	Aug. 4, '81	Feb. 23, '05	B.C.L.S.
McElhanney, Thomas Andrew	Vancouver, B.C	April 21, '86	Mar. 17, '12	
McEwen, Duncan Findlay	Edmonton. Alta	Aug. 7, '73	May 18, '11	A.L.S.
McFadden, Moses	Vancouver, B.C	Aug. 26, '26	April 14, '72	O.L.S., M.L.S.
McFarlane, Walter Graham	Peace River Landing Alta	Sept. 28, '75	May 19, '05	A.L.S.
McFarlane, John Baird	Toronto, Ont	Feb. 25, '79	June 3, '08	A.L.S.
McFee, Angus	Red Deer, Alta	July 14, '46	April 19, '79	A.L.S.
McGeorge, William Graham	Chatham, Ont	Mar. 22, '87	Mar. 21, '10	O.L.S.
McGrandle, Hugh	Wetaskiwin, Alta	Mar. 12, '57	Mar. 30, '83	O.L.S., A.L.S.
McKay, Robert B	Vancouver, B.C	April 21, '83	May 21, '12	
McLean, James Keachie	Ottawa, Ont	Dec. 19, '51	April 1, '82	O.L.S., Dept. of Indian Affairs
McMaster, William Angus Alexander	Prince Albert, Sask.	Feb. 1, '85	July 6, '10	A.L.S., S.L.S.
McMillan, George	Finch, Ont	Dec. 9, '69	Feb. 22, '06	
McNaughton, Alexander L	Cornwall, Ont	Sept. 30, '81	Feb. 23, '05	O.L.S., B.C.L.S.
McPherson, Archibald John	Regina, Sask.	———, '70	Feb. 21, '01	S.L.S.
McPhillips, George	Winnipeg, Man	April 26, '48	June 17, '75	O.L.S., M.L.S., A.L.S.
McPhillips, Robert Charles	Winnipeg, Man	April 24, '56	May 17, '80	M.L.S.
McVittie, Archibald W.	Victoria, B.C	May 5, '58	Mar. 30, '82	B.C.L.S.
Narraway, Athos Maxwell	Ottawa, Ont	July 19, '88	May 18, '11	
Neelands, Rupert A	Hamiota, Man	Aug. 26, '84	Mar. 5, '12	
Nelles, Douglas Henry	Ottawa, Ont	....	Mar. 9, '07	
Neville, Everett A	Ruthven, Ont	Jan. 8, '87	May 18, '11	
O'Hara, Walter Francis	Ottawa, Ont	....	Feb. 19, '95	O.L.S.
Ord, Lewis Redman	Hamilton, Ont	Oct. 17, '56	April 1, '82	O.L.S.
Palmer, Philip Ebenezer	Dorchester, N.B.	May 6, '88	Mar. 7, '12	

APPENDIX No. 10—*Continued.*

LIST of Dominion Land Surveyors who are in possession of Standard Measures—*Continued.*

Name.	Address.	Date of Birth.	Date of Appointment or of Commission.	Remarks.
Parsons, Johnstone Lindsay R.	Regina, Sask.	Jan. 18, '76	Feb. 23, '05	O.L.S., S.L.S.
Patrick, Allan Poyntz	Calgary, Alta.	July 18, '49	Nov. 19, '77	B.C.L.S., D.T.S., A.L.S.
Patten, Thaddeus James	Little Current, Ont.	Feb. 4, '59	Mar. 29, '83	O.L.S.
Pearce, William	Calgary, Alta	Feb. 1, '48	May 10, '80	O.L.S., B.C.L.S., A.L.S.
Pearce, Seabury Kains	Calgary, Alta	Dec. 6, '87	Mar. 9, '11	A.L.S.
Pearson, Hugh Edward	Edmonton, Alta	Oct. 17, '87	May 17, '12	A.L.S.
Pequegnat, Marcel	Berlin, Ont	April 27, '86	June 6, '10	O.L.S.
Peters, Frederic Hatheway	Calgary, Alta	Nov. 4, '83	Mar. 4, '10	A.L.S., Com of Irrigation.
Phillips, Edward Horace	Saskatoon, Sask	Dec. 19, '78	Feb. 24, '02	S.L.S.
Phillips, Harold Geoffrey,	Regina, Sask	Sept. 3, '87	April 23, '10	S.L.S.
Pierce, John Wesley	Ottawa, Ont	....	Dec. 24, '09	O.L.S.
Pinder, George Zouch	Edmonton, Alta	Mar. 5, '81	Mar. 15, '13	
Plunkett, Thomas Hartley	Meaford, Ont	June 1, '78	Mar. 12, '68	
Ponton, Archibald William	Edmonton, Alta	Jan. 25, '59	May 18, '81	O.L.S., A.L.S.
Powell, William Henry	Vancouver, B.C	Dec. 22, '84	Feb. 22, '11	B.C.L.S.
Proudfoot Hume Blake	Saskatoon, Sask	June 23, '58	Mar. 28, '82	O.L.S., S.L.S.
Purser, Ralph Clinton	Windsor, Ont	April 7, '86	Feb. 2, '11	
Rainboth, Edward Joseph	Ottawa, Ont	....	May 19, '81	Q.L.S., O.L.S.
Ransom, John Thomas	Toronto, Ont	Aug. 24, '88	Jan. 14, '11	O.L.S.
Reilly, William Robinson	Regina, Sask	Aug. 10, '57	Nov. 17, '81	O.L.S., M.L.S., S.L.S.
Richard, Joseph Francois	Ste. Anne de la Pocatière, P.Q	....	May 13, '82	Q.L.S.
Rinfret, Claude	Montreal, P.Q	Jan. 5, '86	Mar 20, '08	Q.L.S.
Rinfret, Raoul	Montreal, P.Q	July 16, '56	Feb. 20, '00	Q.L.S.
Ritchie, Joseph Frederick	Prince Rupert, B.C.	May 23, '63	Jan. 7, '89	B.C.L.S.
Roberts, Sydney Archibald	Victoria, B.C	April 10, '48	May 16, '85	B.C.L.S.
Roberts, Vaughan Maurice	Goderich, Ont	Mar. 22, '64	May 17, '86	
Robertson, Donald Fraser	Ottawa, Ont	'80	May 25, '09	Dept. of Indian Affairs.
Robertson, Henry H.	N.Timiskaming, P.Q	Sept. 13, '47	April 14, '72	Q.L.S.
Robinson, Ernest Walter P.	Ottawa, Ont	May 8, '80	May 1, '08	
Robinson, Franklin Joseph	Regina, Sask.	Oct. 20, '70	Feb. 20, '00	S.L.S., Deputy Minister of Public Works.
Robinson, William Andrew	Winnipeg, Man	Feb. 21, '81	Oct. 2, '11	S.L.S.
Rolfson, Orville	Walkerville, Ont	Feb. 26, '85	July 11, '08	
Rombough, Marshall Bedwell	Morden, Man.	Oct. 14, '35	April 14, '72	M.L.S.
Rorke, Louis Valentine	Toronto, Ont	Feb. — '65	Aug. 13, '91	O.L.S., Inspector of Surveys for Ontario.
Ross, George	Welland, Ont	June 12, '53	Nov. 21, '82	O.L.S.
Ross, Joseph Edmund	Kamloops, B.C	Jan. 9, '61	Feb. 12, '91	O.L.S., B.C.L.S.
Routly, Herbert Thomas	Haileybury, Ont	Jan. 20, '78	Feb. 15, '11	O.L.S.
Roy, George Peter	Quebec, P.Q	Oct. 1, '52	Nov. 17, '81	Q.L.S.
Roy, Joseph George Emile,	Quebec, P.Q	Mar. 14, '86	May 25, '10	Q.L.S.
Russell, Alexander Lord	Port Arthur, Ont	....	April 14, '72	O.L.S.
Saint Cyr, Jean Baptiste	Montreal, P.Q	Dec. 17, '66	Feb. 17, '87	Q.L.S.
Saint Cyr, Arthur	Ottawa, Ont	Nov. — '60	Feb. 17, '87	
Saunders, Bryce Johnston	Edmonton, Alta	Oct. 17, '60	Nov. 16, '84	O.L.S.
Scott, Walter Alexander	Calgary, Alta	Aug. 8, '85	Mar. 9, '09	A.L.S., S.L.S.
Seager, Edmund	Kenora, Ont	Nov. 22, '38	April 14, '72	O.L.S.
Segré, Beresford Henry	Davidson, Sask	Feb. 19, '86	May 8, '12	
Seibert, Frederick V	Rush Lake, Sask	Nov. 5, '85	Mar. 11, '11	O.L.S.
Sewell, Henry DeQuincy	Toronto, Ont	April 18, '48	May 16, '85	O.L.S.
Seymour, Horace Llewellyn	Red Deer, Alta	June 11, '82	Feb. 22, '06	O.L.S., A.L.S., S.L.S.
Shaw, Charles Æneas	Greenwood, B.C	Nov. 16, '53	May 10, '80	O.L.S., B.C.L.S.
Shepley, Joseph Drummond	N. Battleford, Sask.	Sept. 13, '79	Mar. 12, '06	S.L.S.
Smith, Charles Campbell	Vanconver, B.C	Jan. 1, '73	Feb. 22, '06	O.L.S.
Smith Donald Alpine	Regina, Sask	Sept. 22, '80	April 21, '10	S.L.S.
Smith, James Herbert	Edmonton, Alta	Nov. 9, '76	Feb. 23, '05	A.L.S., O.L.S.
Soars, Henry Martin Robinson	Edmonton, Alta	April 22, '77	Nov. 2, '08	A.L.S.
Speight, Thomas Bailey	Toronto, Ont	Feb. 8, '59	Nov. 16, '82	O.L.S.
Starkey, Samuel M.	Codys, N.B	Sept. 4, '37	April 14, '72	P.L.S. for N.B.
Steele, Ira John	Ottawa, Ont	April 6, '81	April 16, '08	O.L.S.

APPENDIX No. 10—*Concluded.*

LIST of Dominion Land Surveyors who are in possession of Standard Measures.—*Concluded.*

Name.	Address.	Date of Birth.	Date of Appointment or of Commission.	Remarks.
Stewart, Elihu	Collingwood, Ont	Nov. 17, '44	April 14, '72	O.L.S.
Stewart, Lionel Douglas N	Collingwood, Ont		Jan. 27, '10	O.L.S.
Stewart, Will Malcolm	Saskatoon, Sask	Nov. 26, '84	June 6, '07	S.L.S.
Stewart, Louis Beaufort	Toronto, Ont	Jan. 27, '61	Nov. 22, '82	O.L.S., D.T.S. Professor of Surveying and Geodesy, University of Toronto.
Stewart, Alexander George	Edmonton, Alta	Aug. 16, '87	Mar. 14, '10	A.L.S.
Stewart, George Alexander			April 14, '72	O.L.S.
Stewart, Norman C	Ottawa, Ont	Jan. 9, '85	March 7, '12	
Stock, James Joseph	Ottawa, Ont	Aug. 16, '87	March 2, '10	
Street, Paul Bishop	Toronto, Ont	Dec. 3, '81	Mar. 29, '10	
Stuart, Alexander Graham	Buckingham, P.Q	July 16, '88	May 9, '11	
Summers, Gordon Foster	Haileybury, Ont		Oct. 20, '10	O.L.S.
Swannell, Frank Cyril	Victoria, B.C		May 10, '04	B.C.L.S.
Taggart, Charles Henry	Ottawa, Ont	'83	May 9, '11	
Talbot, Albert Charles	Calgary, Alta	April 5, '56	May 13, '80	A.L.S.
Taylor, Alexander	Portage la Prairie, Man	Aug. 6, '75	June 9, '04	M.L.S., S.L.S.
Taylor, William Emerson	Owen Sound, Ont	Aug. 3, '81	Dec. 16, '10	O.L.S.
Teasdale, Charles Montgomery	Concord, Ont	Oct. 18, '79	March 9, '06	
Thompson, William Thomas	Grenfell, Sask	Nov. 1, '53	Nov. 19, '77	D.T.S., S.L.S.
Tipper George Adrian	Brantford, Ont	July 25, '86	May 18, '11	
Tracy, Thomas Henry	Vancouver, B.C.	June 25, '48	April 14, '72	O.L.S., B.C.L.S.
Tremblay, Alfred Joseph	Les Eboulements, P.Q.		Feb. 18, '99	
Tremblay, Albert Jacques	Edmonton, Alta	July 25, '87	March 1, '12	A.L.S.
Turnbull, Thomas	Winnipeg, Man	May 26, '57	Mar. 29, '82	O.L.S.
Tyrrell, James William	Hamilton, Ont	May 10, '63	Feb. 16, '87	O.L.S.
Underwood, Joseph Edwin	Saskatoon, Sask	Nov. 3, '82	May 18, '11	S.L.S.
Vaughan, Josephus Wyatt	Vancouver, B.C	Oct. 17, '45	June 11, '78	B.C.L.S.
Vicars, John Richard Odlum	Kamloops, B.C	April 16, '55	May 17, '86	O.L.S., B.C.L.S.
Vickers, Thomas Newell	N. Battleford, Sask	April 19, '90	May 17, '12	
Von Edeskuty, Joseph Otto	Vancouver, B.C	Oct. 27, '84	March 3, '13	
Waddell, William Henry	Edmonton, Alta	March 23, '83	Mar. 25, '07	O.L.S., A.L.S.
Waldron, John	Moosejaw, Sask	Aug. 1, '72	April 2, '07	S.L.S.
Walker, Claude Melville	Guelph, Ont	Oct. 16, '84	Mar. 11, '11	
Wallace, James Nevin	Calgary, Alta	Aug. 21, '70	Feb. 20, '00	O.L.S., A.L.S.
Warren, James	Walkerton, Ont	Nov. 7, '37	April 14, '72	O.L.S.
Watt, George Herbert	Ottawa, Ont	Feb. 5, '76	Feb. 24, '02	
Waugh, Bruce Wallace	Ottawa, Ont	March 24, '88	May 28, '12	
Weekes, Abel Seneca	Edmonton, Alta	Feb. 17, '66	Feb. 11, '92	A.L.S., S.L.S.
Weekes, Melville Bell	Regina, Sask	Nov. 28, '74	Feb. 18, '03	O.L.S., S.L.S.
Wheeler, Arthur Oliver	Sidney, B.C	May 1, '60	Nov. 21, '82	O.L.S., B.C.L.S., M.L.S., A.L.S.
White-Fraser, George W. R. M.	Victoria, B.C	'61	Feb. 21, '88	D.T.S., B.C.L.S.
Wiggins, Thomas Henry	Saskatoon, Sask	Aug. 24, '63	Feb. 18, '96	O.L.S., S.L.S.
Wilkins, Frederick, W. B	Norwood, Ont	June 27, '54	May 18, '81	O.L.S., D.T.S.
Wilkinson, William Downing	Not known		Feb. 22, '93	
Williams, Guy Lorne	Enderby, B.C	March 3, '79	June 24, '08	B.C.L.S.
Wilson, Reginald Palliser	Winnipeg, Man	July 9, '72	Jan. 26, '11	M.L.S.
Woods, Joseph Edward	Pincher Creek, Alta	Oct. 13, '61	Nov. 14, '85	A.L.S.
Young Walter Beatty	Winnipeg, Man	July 6, '80	Mar. 25, '05	M.L.S.
Young William Howard	Calgary, Alta	June 8, '78	May 17, '07	A.L.S. District Engineer

REPORTS OF SURVEYORS

GENERAL REPORTS OF SURVEYS

1912-13

APPENDIX No. 11.

ABSTRACT OF THE REPORT OF J. R. AKINS, D.L.S.

BASE LINE SURVEYS IN PEACE RIVER DISTRICT.

I reached Edmonton on February 16, 1912, and having organized my party and shipped my supplies I left on the 26th for the Peace river district, the scene of my survey operations.

The route followed was by way of Grouard, Sturgeon Lake, Grande Prairie and Pouce Coupé district.

As the Canadian Northern railway was not yet completed to Athabaska Landing we went north by trail. There was very little snow, and the horses had hard work to pull the almost empty sleighs. A wagon was hired to help us as far as Athabaska Landing, where we took to the ice. From there the trail was fine and the ice in good condition so that we had good travelling as far as Pouce Coupé, where we arrived on March 23.

For the last few days the snow had been going very fast and the day following our arrival at Pouce Coupé it had almost all gone. Wagons were used for another ten miles and then we had to resort to our pack train. The spring is, without doubt, the best time for getting into this country. Work was commenced on the twentieth base line on April 3, and the west boundary of the Peace river block was reached on July 3. The country passed through was rough and hilly and consequently the work proceeded slowly, the levelling being especially difficult.

The month of June was very dry and we had considerable trouble getting observations, as there was much haze and smoke.

After completing this work we left for the twenty-third base line. Peace river was crossed at Fort St. John by swimming the horses and putting the outfit over in boats.

Work was commenced on the base line on July 27 and the sixth meridian was reached on September 4.

Very little horse feed was found along this line and on one occasion the pack train had to go fourteen miles from camp in order to get feed.

The fall of 1912 was exceedingly dry in this district, and the many fires which broke out caused much anxiety and trouble. As many as nine fires were counted around us at one time, and on one occasion we had to fight fires night and day for three days in order to save the horses and outfit. The country was burned over for more than one hundred miles north of Dunvegan.

The sixth meridian was corrected between townships 88 and 84, after which work was commenced on the twenty-second base line. After running fifteen miles of this line we came to burnt country and were forced to quit on account of not being able to secure horse feed. As there was yet no snow or ice, however, we were unable to leave for home. It was then the middle of November, and as snow might come at any time it was decided to do some outline work in the district not burnt over, while waiting.

On December 1, it began to snow and turned cold, the temperature falling to 30 degrees below zero. On the 5th we started for home, having run over one hundred and fifty miles of line during the season.

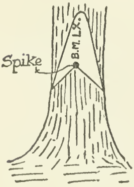
On December 6 a 'chinook' wind took away nearly all the snow. However, some ice was still left on the roads and on this the sleighs slipped fairly well, so that we were enabled to reach Grouard on the 14th. After doing a couple of days' work there,

ascertaining the area of land in some fractional quarter sections, we started for Edmonton, where we arrived on December 24.

LEVELS.

Levels were taken along the base lines run during the season, the work being checked by a second line of levels. It was found necessary to resort to trigonometric methods for taking the levels along the twentieth base, as it was impossible to keep up the work with one level. Long sights were also taken across many of the deep valleys and ravines. Great care was used in taking these sights. The instrument was set up at one side of the valley and ten or twelve readings were taken by means of the target on the other side. The positions of the rod and level were then reversed and readings taken the opposite way. The extremes of a set of readings would be about one-tenth of a foot. The mean of each set were taken as the correct reading. The instrument was tested before and after each set was taken and the necessary correction, together with the correction for curvature and refraction, was applied. The readings to the west were taken in the morning about five o'clock, and those to the east in the evening after six o'clock. Sights of over a mile were taken in this manner and splendid results were obtained. The elevation of the bottom of the ravine or valley was obtained by running a single line of levels down one side or by reading angles with the transit.

Where the distance was too great to take sights in this manner, spirit levels were run all the way across, and where the slopes were not too steep these were checked by another line of spirit levels; where steep slopes were encountered they were checked by trigonometric levelling. The transit used for this purpose had a six-inch vertical circle graduated to 0.004 degrees (about 14 seconds). No sights were taken longer than five chains. The distance was obtained by holding one end of the chain at the axis of the transit, with the other at the centre of the target, and a strong pull was put on the chain. The two verniers were read with the telescope both direct and reversed, and the mean taken. For each slope two sets of triangles were taken as a check on each other, and remarkable results were obtained, especially when done on cloudy days, in the early morning or in the evening, and we had no trouble in checking within the limits of one-tenth of a foot to the mile. On the other lines, no difficulty was found, as the country was not rough.



Bench marks were made at intervals of about one mile. These were made on large boulders or rocks, or where these could not be found, by driving a spike into a tree and making a blaze above it with the letters 'B.M.' and the number cut on it as shown by the diagram.

Where a rock or large boulder could not be found within four miles of the last one used, a permanent bench mark was made by bending an iron post about six inches from the end, digging a hole and planting the post with about ten inches showing above the ground. The elevation recorded was the top of the iron post, and in the case of the bench marks on the trees it was the top of the spike.

CHAINING.

Every precaution was taken to obtain accuracy in the chaining. The chains were tested by comparison with the standard supplied by the Department, the test being made in the following manner:—

A straight log of over a chain in length was chosen on which the standard was laid and subjected to a tension of twenty pounds, and a length of one chain was marked on the log. The chains used in chaining on the line were tested by this length giving them also a twenty-pound pull, and each one hundred links or sixty-six feet was tested separately. In practice, the chain was cleared so as to have no bends in it and a pull of about twenty pounds put on it before the distance was marked by dropping a narrow brass plumb-bob. Each half mile was checked separately, the first chainage being done with a four or five hundred link tape, the second with a three hundred foot tape. This eliminated the chance of any error of an even number of chains being made in any chainage.

Both front and rear chainmen carried clinometers with which they read the slope, and each recorded his own readings. At the end of the half mile each worked out his slopes independently. If the results obtained by each were nearly the same the mean was taken as the right slope correction for the first chainage. The same procedure was followed in the second chaining, and if the two chainages checked to within a link the post was planted at the mean of the two results thus obtained.

In the hilly country I consider two clinometers very necessary in chaining, one being used as a check on the other. Clinometers are liable to get out of adjustment sufficiently to make a considerable error in the work. Several times during the season I found it necessary to readjust the ones we were using and one was discarded altogether as it would not remain for any length of time in adjustment. If only one clinometer be used it may be considerably out without being detected unless the angle is also read with the clinometer in reversed position.

APPENDIX No. 12.

ABSTRACT OF THE REPORT OF C. F. AYLSWORTH, D.L.S.

RESURVEYS IN MANITOBA.

I left home on April 23, 1912, organized my party at Winnipeg, and proceeded to township 18, range 1, east of the principal meridian, where I was to make some resurveys.

In this and the surrounding townships the soil is of good quality, but surface stones, principally limestone, are numerous, and the land is very wet. A good quality of lime can be produced from the limestone, and when the land is drained and the stones removed the soil will be first-class for farming purposes. Timothy and clover grow well, and the vegetable products of the district cannot be excelled. Last year a considerable amount of wheat was shipped from Inwood, a station on the Canadian Northern railway.

Having completed the resurvey work in township 18, range 1, on June 5, I left the following day for township 16, range 6, and did some retracement survey near the mouth of Brokenhead river. Most of the lines I retraced in this locality lie in the drowned lands and lagoons on the south shore of lake Winnipeg. The depth of water varies with the direction of the wind. When the wind blows from the north and west down the lake, the water is forced over the land to a depth depending on the velocity and duration of the wind. Brokenhead river can then be navigated for a few miles up-stream from its mouth. When the wind is in the opposite direction the flat-bottom stern-wheel boats which ply these waters are frequently compelled to "stand off" for days awaiting a sufficient depth of water to enable them to cross the shifting sandbars which lie at the mouth of the river.

A branch of the Canadian Northern railway is now under construction from Winnipeg to Balsam bay, which lies a few miles easterly from the mouth of Brokenhead river. This branch runs through country which is mostly muskeg, and in order to secure a solid road-bed the railway company dug large ditches on both sides of their right of way. These ditches drain the land through which the railway runs, and carry an immense volume of water to lake Winnipeg. Extending from the mouth of Brokenhead river easterly to Balsam Bay is a splendid bathing beach. The bottom consists of a velvety sand, and the depth of the water within ten chains of the shore, does not reach the average height of a man. This beach, with its background of balsam and spruce on the uplands, would make an ideal location for a summer resort.

I finished the work in this locality on July 3, and left for township 25, range 6, east of the principal meridian, which lies on the north end of Hecla island in lake Winnipeg. For half a mile inland on this island the land is high and dry, and was at one time heavily wooded with poplar, spruce, birch and balsam. This strip has been recently overrun by fire, and it was somewhat difficult to locate the old survey monuments. The soil is sandy loam, stony, and underlaid at a depth of one to six feet with stratified shaly limestone. Farther inland is a low tamarack and spruce muskeg which will be valueless when the timber is removed.

The settlers, all of whom live on the strip along the shore, are of Icelandic descent, and live by fishing, though farming to a very small extent is practised.

On the east side of the island, in section 27, a large gang of men are employed in a limestone quarry, which is well equipped with modern machinery, and large quantities of stone for building purposes are conveyed on barges to Winnipeg. Many

quarry claims are staked out in sections 13 and 24, where it is intended to operate another quarry. Gull harbour on the east coast is becoming popular as a summer resort, and the establishment of a Dominion fish hatchery there renders it more important.

Wild raspberries grow on the island in great profusion, and no doubt fruits of many varieties would thrive. On an adjoining island silica sand has been discovered, and it is used extensively at the Beausejour glass factory to manufacture a very clear grade of glass.

On August 29 this work was finished, and I left by steamer for Selkirk, and thence to townships 22 and 23, range 5, west of the principal meridian. Nearly all the land in these townships is taken up. The surface is low and wet; about one-third is muskeg, and most of the remainder is poplar brulé, with considerable stone on the surface. The soil is very rich, but extensive drainage operations are necessary to make good farming land. A fairly large amount of green timber grows in township 23, but very little is found in township 22.

The Oak Point branch of the Canadian Northern railway crosses the southwest quarter of township 22, and some wheat was shipped from Ericksdale, a station in section 4. A passenger train service was inaugurated on this line a few days before we left the district, and the trains were loaded with passengers. This hitherto avoided portion of Manitoba appears to be coming into prominence.

As the ground was exceptionally late in freezing, I did not close operations until December 2.

APPENDIX No. 13.

ABSTRACT OF THE REPORT OF P. R. A. BELANGER, D.L.S.

MISCELLANEOUS SURVEYS AND INSPECTION OF SURVEY CONTRACTS IN MANITOBA AND EASTERN SASKATCHEWAN.

Before commencing my field operations I examined the iron posts made by the Taggart Ornamental Iron Works, of St. Boniface. On April 18, 1912, I left for the inspection of contract No. 5 of 1911, comprising township 39, range 4, and townships 39 and 40, ranges 5, 6 and 7, west of the second meridian.

Owing to slow progress, caused by the heavy rains which prevailed in May, rendering the roads impassable and making the rivers too deep to ford, this work kept us busy until May 20. These townships are accessible from Sturgis and Preeceville, by wagon roads leading from these stations along Lilian river into valley of Etomami river which runs northerly in range 5 to near the centre of township 40, where it is joined by Piwei river. From the junction of these rivers the road turns westerly along the north side of Piwei river and, meandering across the northern part of townships 40, ranges 5, 6 and 7 in the direction of Piwei lake, branches southwesterly in range 8 towards Nut Lake settlement, which is accessible by two different branches of the road after Piwei river has been crossed.

The country covered by this contract is rather bushy, except the part lying north of Piwei river, which has been considerably opened by fires, and where large tracts of land are ready for immediate settlement. A small cattle ranch owned by a Mr. White is located in the valley of Piwei river, in township 40, range 7, his cattle running all along the opening above described. He is at present at a great disadvantage on account of having to haul his hay supply a long distance over a rough road.

At the crossing of Piwei river, I entered contract No. 6, of 1911, where I inspected four townships. The country covered by this contract in ranges 8 and 9 shows a great improvement on that covered by the one just described; its character is generally rolling, open and well watered by numerous creeks, small lakes and sloughs, along and around which good hay is found in fair quantities. This country is reached by fairly good roads leading from Wadena and Tisdale railway stations through the settlements of Nut Lake, Farmingdale or Kelvington. These roads render this section very suitable for immediate settlement.

On June 10, having completed the work I had to do in Saskatchewan, I proceeded to Wadena where I shipped my outfit by rail, and boarded the train for Winnipegosis, reaching there on the 15th, after a stop-over at Dauphin for two days awaiting train connection.

From Winnipegosis, my party drove to Camperville and thence to township 35, range 21, west of the principal meridian, for the inspection of contract No. 4 of 1911, while I myself made a flying trip to Oak Point settlement for the purpose of hiring a boatman to bring my sailboat from that place to Winnipegosis. On my return to Winnipegosis I found my sail-boat had not yet arrived owing to the lack of wind to sail her up against the current of Waterhen river. I therefore despatched a small gasoline boat to bring it into the harbour, and on its arrival next day, I sailed to Camperville where I met my party which had just completed the inspection of two townships. On the following morning, after loading the camp equipage on the boat, I sailed to Duck bay. We camped at night on the bank of Insect river, in township 37, range 20. From this camp I made the inspection of that township, together with a traverse of part of Duck bay and, after another short move of camp northerly

G. H. Herriot, D.L.S.
Loading Dog Sleighs on Moose Lake, Manitoba.

Photo. by G. H. Herriot, D.L.S.
Rapids on Nelson River above Cross Lake.

along the bay shore, I completed the inspection of this contract in township 38, range 20. Judging from the part examined, the country included therein is very low and wet, and practically unfit for settlement; it consists mostly of tamarack swamps or bare boggy muskegs; a few small dry elevations, where small farms could be established, are found in township 35, range 21, along the stream known as North Duck river and also in township 37, range 20. In the latter township there are numerous good hay marshes where quantities of hay can be secured, but the great drawback is the lack of proper roads, the only good way to reach the district being by the water route from Winnipegosis or Camperville. As a compensation for all these inconveniences, intending settlers would have the prospect of making money in fall and winter time with the fish and fur trade which is still remunerative.

On July 12, having completed the inspection of contract No. 4, of 1911, I returned to Camperville. My assistants and some of the party took the outfit by trail to Winnipegosis, while I, with a few men, sailed to the same place with the remainder of the baggage, reaching there on the morning of the 16th. After disposing of my boats, I left on the next day by train for Portage la Prairie, whence I drove to township 14, range 6, for the purpose of making resurveys at the south end of lake Manitoba. However, after a trial on two different lines, I found it impossible to proceed with the work as the water in the lake was two feet higher than usual, and the whole land to be surveyed was flooded to such a depth that I had no other alternative than to postpone this work until winter.

From this place I drove to Oak Point and once more put my outfit on the train to reach contract No. 2, of 1911, in township 28, range 8, where I arrived on the 24th. Here the party was busy until August 12, inspecting four townships of the contract. These townships may be described as generally level, with a few small ridges. The land is fairly good and well interspersed with hay marshes, supplying all the hay necessary for a large settlement. The northern part of township 29, range 8, is partly covered by lake St. Martin, which abounds with good fish, such as whitefish, pickerel, pike and gold-eye. All around this lake is found a large belt of fine hay land which renders this township very desirable for cattle raising on a large scale. The Canadian Northern railway crosses this contract in ranges 8 and 9, thus affording great advantage to the settlers who were already coming in at the time of the inspection.

On August 13 we boarded the train with the outfit for Pleasant Point, a station on the Canadian Northern railway in township 10, range 13, west of the principal meridian, for the purpose of resurveying part of township 8, range 12. My work there was limited to the resurvey of sections 27 to 34, inclusive, where all marks were found obliterated. I also retraced the lines and restored the monuments marking the east boundaries of sections 3, 10, 15 and 22, and connected the same with the resurvey of the east boundary of section 27. In this township all the available good land and other resources have been disposed of.

In the beginning of September, while my assistants and party were continuing the subdivision survey in the township above referred to, I went once more to Clandeboye bay where, after procuring the services of an experienced canoeman of St. Mark, I spent three days running picket lines in townships 14, ranges 5 and 6, to temporarily mark the boundaries of the Kirchhoffer Shooting Club property until a regular survey could be made on the ice. This work was caried on with success, and I believe it answered the purpose of defining the boundaries of the property for the protection of the game on account of the intended visit of His Royal Highness the Duke of Connaught to this shooting ground.

From Pleasant Point, my next move was towards Prince Albert, which place I reached by rail on September 14, but the outfit did not arrive until the night of the 16th, and could not be unloaded from the car before the next day. From there, after securing my supplies, I proceeded northerly to inspect contract No. 18, of 1912, which kept me busy until October 2. This contract covers townships 54 to 56, range 1, and

township 56, range 2, west of the third meridian. These townships are rather heavily timbered, principally along the parts adjoining the timber berths. The country is hilly in the vicinity of Spruce river, which flows southerly across the three townships of range 1, draining townships 55 and 56, ranges 1 and 2, where the divide and height of land appears to run in a southwesterly and northeasterly direction. In township 56, range 2, the Prince Albert Lumber company have cut a short channel to divert a creek emptying into Montreal lake and bring its waters southerly into Spruce river, which empties into Saskatchewan river.

After completing this contract I undertook a seven days' journey to reach contract No. 20, of 1912, which, though only about eighteen miles west of contract No. 18, was accessible only by a circuitous route of over one hundred miles by way of Sturgeon lake, McOwan, Mount Nebo, Boutin and Big River. This contract covers townships 56 to 58, range 6, and townships 56 and 57, range 7, west of the third meridian. These townships are situated at the height of land on the north side of the divide and are mostly covered with timber, but fires have run over the country and made some openings in range 7. The land is fair, but it is badly broken by lake Delaronde and by numerous other lakes and muskegs. A few settlers have already forced their way into this country, which, on account of its close proximity to Big River village offers some opportunities for the sale of their products.

The village of Big River is situated in the southwest corner of township 56, range 7, at the south end of Cowan lake. It is now the actual terminus of a branch of the Canadian Northern railway. The Big River Lumber company owns the greater part of the village, besides large sawmills, where hundreds of men are employed all the year; so that settlers taking land near Big River will always be sure to find work at the sawmill when not working on their homesteads, and also a market for their products.

From this place, I returned to Prince Albert by rail, and then drove about fifty miles northeast to contract No. 17, of 1912, which covers townships 52 and 53, ranges 19 and 20, west of the second meridian. The road I followed to that contract passes through Henribourg settlement, and then turns east to a small Galician settlement where I struck a new road cut out a few years ago by the Hudson Bay and Pacific Railway company, and which runs across three townships of this contract. This whole road is very primitive and rough, and needs great improvement, but it is the only one by which this country can be reached.

Leaving this place, I reached the adjoining contract No. 16 by following a road cut easterly by the contractor who, I am informed, also cut another road southerly to Fort à la Corne.

Judging from what I have seen, very little land in these two contracts is fit for settlement, though the country has been much opened by fire. It is generally low and covered with numerous swamps or muskegs which were flooded by the heavy rains prevailing during last summer. The only place where homesteads could be found is along creeks, where tracts of fair land are met with, and where enough hay is found to permit of mixed farming. The draining and opening of this country might improve it to a great extent, and a dry season would also present it in quite a different aspect.

The chief aid in the development of this country will be the construction of the Hudson Bay and Pacific railway, the location line of which runs in a northeasterly direction across townships 52 and 53, range 20, and township 53, range 19.

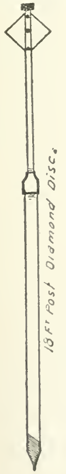
On November 7, having completed my inspection, I returned to Prince Albert *via* Henribourg, where I delivered my transport outfit to Mr. B. Nicholson for wintering. This journey was accomplished under great hardship, through snowstorms which lasted during two days, leaving eighteen inches of snow on the ground and covering the little grass or hay that was to be found along the road.

From Prince Albert I went to Hudson Bay Junction, a station on the Canadian Northern railway, where I spent five days surveying a few lines in connection with

timber berth No. 1920, situated in township 44, range 4, west of the second meridian. I then resumed my journey *via* Winnipeg to Cypress River, a station on the Souris-Arcola-Regina branch of the Canadian Pacific railway, for the purpose of traversing Assiniboine river across township 8, range 12, west of the principal meridian, which work had been omitted at the time of resurvey. After the completion of this survey, I returned to Winnipeg, where I discharged my party on November 30, postponing once more the survey required in townships 14, ranges 5 and 6, west of the principal meridian, owing to the fact that this marshy country was not yet frozen. I attended to this work with my assistant and a few men that I had hired on the spot, at St. Mark. I succeeded in retracing all lines, and re-established the monuments that were missing.

As this land, as well as the adjoining country, is mostly all covered with deep water or long reeds, and is owned by hunters who are anxious to protect their game against trespassers and poachers, I marked it with special iron posts, some sixteen feet and others eighteen feet in length, and generally showing about six feet above water, or a couple of feet above the reeds. The posts placed at corners in deep water are eighteen feet long and were driven from five and a half to seven feet into the ground. One post, marking the northwest angle of the reserve on lake Manitoba beach, is only six feet long, and will show three feet above the ground.

All posts on the side lines are surmounted with heavy diamond-shaped sheet iron plates with fourteen-inch sides which are painted red. They are attached by three rivets, and placed in the direction of the lines. The two posts marking the southeast and southwest angles have plates fourteen inches wide and twenty-four inches long bent in the middle at right angles to indicate the direction of the lines from the corners. Six inches below the plates are found the figures '$\frac{1}{4}$' or the section number indicating the corner which the post is intended to mark.



These posts are made in two pieces. The lower part is ten feet in length in the sixteen-foot posts, and twelve feet in length in the eighteen-foot posts, and is made of iron tubing one inch inside diameter. It is plugged and sharpened at the point, and threaded at the upper end. The upper part is six feet in length and is made of half-inch tubing, threaded at both ends. The two parts are fastened together by a connection which is adapted to the two sizes of tubing. A cap screwed on the top of these posts, and below the cap the plate above referred to, is attached by means of three rivets.

These posts are sufficiently noticeable to be seen by anybody and to prevent all trespassing. They should last for half a century, if properly cared for by the land-owners.

In the course of my travels in Manitoba and Saskatchewan I noticed the great movement which is going on in colonization, and which is increasing steadily year by year. The new settlers follow the trend of surveys, and were met with everywhere.

Small and large game appears to be nearly as plentiful as in the past, nothwithstanding the great slaughter which occurs every year, and fish are abundant in all the waters.

No minerals were found during the course of the season's surveys.

Lumbering is still carried on on a very large scale in the Prince Albert district, where hundreds of men are employed the year round by the different companies.

Railways are extending in all directions and prove a great blessing to the settlers, as well as assisting in the development of the country.

APPENDIX No. 14.

ABSTRACT OF THE REPORT OF G. A. BENNETT, D.L.S.

MISCELLANEOUS SURVEYS IN MANITOBA AND EASTERN SASKATCHEWAN.

These surveys varied greatly in character. They consisted in locating and correcting, where possible, errors in previous surveys, destroying duplicate monuments, restoring obliterated monuments and re-establishing lost monuments, traversing lakes, the boundaries of which have changed since the previous surveys, completing parts of subdivision and connecting surveys omitted by the original survey, and also investigating various errors which had been reported to the Department by settlers.

On account of the expense in travelling the long distances between the different surveys, I was accompanied on this work by only one assistant. Labourers were engaged locally when necessary and wherever possible. Most of the surveys were made in the bush country, and men were readily secured as needed, except during the harvest season, when farmers were offering labourers $7 per day to work in the wheat fields, and every man who desired work was employed. A detailed account of the surveys made is as follows:

On May 5, 1912, I arrived at Togo, Sask., and began the season's surveys. A few miles from this growing village, a large discrepancy had been reported to exist in the original survey. By retracing, I found a considerable error in the position of one of the boundary monuments and, upon petition of all the owners of lands affected, this monument was destroyed and a new monument erected at the true corner.

This district has made great progress during the last five years. When the land was first homesteaded progress was slow on account of the country being largely covered with scrub, but to-day the bluffs have disappeared from many sections and large quantities of wheat and oats are grown for export. Having completed this survey on May 8, I travelled to McCreary by the Canadian Northern railway, but found it impracticable to make the required surveys in this district, on account of the flooded condition of the country. I therefore proceeded to Sandy lake and, with the aid of a rented canoe, was able to complete, in a couple of days, the retracement surveys required to obtain the information necessary to correct the returns of the original survey of township 18, range 20, west of the principal meridian.

During the month of May, it was very rainy in the district about the Riding mountains in northern Manitoba. Large areas of the level country at the foot of the hills were flooded to an unusual depth, making the trails impassable. On account of these conditions, I travelled around to the east side of lake Manitoba on May 15 and found that the heavy rains, which were flooding the western part of the province of Manitoba, had not extended east of the lake. The trails were in fair condition and rapid progress was made in resurveying some lands in townships 15 and 16, range 4, and retracing parts of townships 21, ranges 4 and 7, west of the principal meridian. The purpose of these surveys was to make possible the issue of correct township plans showing the present shore of lake Manitoba and the true bearings and distances of section lines not correctly returned by previous surveys. As the land in this district rises gradually from lake Manitoba, a small change in the water level of the lake greatly alters the shore line. As meadow lines of considerable value border the lake, errors in the survey are of importance. These hay meadows have been utilized by small ranchers for the last twenty years, but it is only recently that the timbered country back from the lake has been settled. The branch of the Canadian Northern railway from Winnipeg to Gypsumville has opened up this district and as the main

roads are cut out and graded across the numerous muskegs, the homesteaders are getting better communications with the small villages springing up along the railway. Thus encouraged, the settlers are busy clearing up their homesteads, and already many fields of wheat and oats were noticed, but mixed farming is now, and will be, the staple industry here. The winter fishery on lake Manitoba is also a profitable employment for many of the settlers, while the numerous moose and elk provide food for the settlers in the newer districts.

On May 29, I completed these surveys and started for Norquay, Sask. Near this growing village I surveyed two lakes in township 34, range 1, west of the second meridian, which had been overlooked when making the original survey. This district has made rapid progress during the last few years. Graded roads extend miles from the railway, and rural telephones are found in the homes of most of the settlers. Formerly the land was covered with poplar scrub, but to-day many large fields of cultivated land are found, with numerous granaries, attesting to the productiveness of the clay loam soil.

The next survey was made in township 33, range 19, west of the principal meridian, to investigate a reported duplicate monument. I reached this work, after a two days' drive north from the town of Winnipegosis over a poor trail, which follows up to the west shore of lake Winnipegosis. Locating the duplicate monument on the flood land near the shore of lake Winnipegosis, I performed the necessary retracement, destroyed the false monument and renewed the true monument. The settlement north of the town of Winnipegosis is restricted to the lands near the shore of the lake, as the interior consists of a muskeg, which will have to be drained before the land becomes of agricultural value. However, the settlers are fairly prosperous. During the summer, they are employed in mixed farming, while the winter fishery affords them a ready market for their produce and profitable employment at the time of the year when the prairie homesteader has nothing to do.

June 22, I began a retracement survey in township 6, range 14, west of the second meridian, near the town of Weyburn, Sask., where large errors were found in the original survey. These discrepancies between the true acreage of the sections and that indicated by the titles were causing severe losses to unsuspecting buyers of land in the township. This district is undulating prairie. The land was homesteaded about fifteen years ago, and to-day the farmers have good roads, rural telephones, fine houses and outbuildings. The bountiful harvests of wheat have rendered them well-to-do within a few years.

On July 1, I visited township 31, range 31, west of the principal meridian, and made a resurvey to locate the southeast corner of this township, which is made fractional by the Coté Indian reserve. Most of the land in this district has been homesteaded by Galicians. Isolated from towns by almost impassable roads, these people live for a large part of the year on the produce of their cattle and poultry and their national black bread, and have become little Canadianized. However, the small clearings in the thick forest about their thatched log houses are being constantly increased, and soon it is hoped they shall secure schools, roads and the other advantages of civilization.

The retracement survey of part of township 21, range 14, west of the principal meridian, was next attempted. The dry weather had rendered the trails out of the village of McCreary now passable and the work was reached without much difficulty. As the original survey of this township was thirty-seven years ago, most of the monuments and marks left by that survey had disappeared and I found that all the homesteaders on the southeastern part of the township had located themselves erroneously and made their improvements upon different quarters than those which they had applied for. This is a severe set-back to the more enterprising settlers, as they lose the work of years in clearing and breaking the land, and have to move their buildings at a heavy expense.

This district is well adapted for mixed farming. This year a large drainage canal was dredged, which will dry up the muskegs and render the trails to the township more passable, as well as protecting the farmers from the floods, which in the past have reduced their activities to stock raising and lumbering.

On July 13, I began a retracement survey of part of township 18, range 10, west of the principal meridian. Three blocks were retraced before proper closings of the survey were obtained. Many of the monuments of the original survey were lost, and some of the homesteaders were so uncertain as to their location that they hesitated to make improvements. This country had been burned over several times and the land is easily cleared of the brulé and scrub which is left. The soil consists of sandy loam, somewhat stony in places. The large drainage ditches dredged this year will do much to dry up the many large muskegs, which render many homesteads difficult of access at present.

A restoration survey was next made, at the request of the Director of Forestry, of the boundaries of section 6, township 20, range 20, west of the principal meridian, in the Riding Mountain Forest reserve.

On August 10, I began a correction survey of part of township 14, range 4, west of the second meridian, petitioned for by owners of lands affected by mistakes in the original survey. The land surveyed consisted of rich prairie, a large percentage of which was cultivated and gave promise of a fine yield of wheat this season. This district has been settled twenty-five years and the farmers are well-to-do and have as fine houses and bank barns as may be seen in Ontario.

The next work consisted of investigating a lake in townships 5, ranges 15 and 16, west of the second meridian, which had been reported to have partially dried up. A survey was made to correct the original plan, so as to include the lands rendered of value by the drying up of the lake.

This township has changed lately from a ranching to a farming district. The soil, consisting of a heavy white clay with much of the humus burnt off, does not seem adapted to wheat growing, so the hay meadows around the lakes and sloughs are much sought after by the settlers to assist them in mixed farming.

Completing this survey on August 16, I returned to Manitoba and left the railway at Deer Horn siding on the Gypsumville branch of the Canadian Northern railway, to proceed to township 21, range 2, west of the principal meridian. By previous arrangement, a team and a driver met me at the siding and we set out at once for the work. This was necessary, as there is little settlement here near the railway. Following the trail by Vannes and the old surveyors' trails east, I had little difficulty in getting across the muskegs with a team to reach the work. Here some hardship was experienced on account of the rainy weather, as there was no settlement in township 21, range 2, west of the principal meridian and I did not carry around with me a regular camp outfit. However, I completed the surveys required, which consisted of destroying a witness monument incorrectly placed by the original survey upon the road allowance, and ascertaining the character of another monument incorrectly returned, together with the retracement of all connecting section lines.

As there is considerable hay in this district, a few ranchers could do well here, but several deserted shacks of homesteaders to be found in township 21, range 3, west of the principal meridian, show that the floods and bad roads in spring and summer render settlement difficult at present. It is probable that when the branch line of the Canadian Northern railway is completed north from Inwood that settlers will come into this country from the east.

The next survey made consisted in laying out the boundary of Dominion lands along the Dog Creek Indian reserve and the retracing of several section lines to effect proper closings in township 22, range 8, west of the principal meridian.

On September 11, I proceeded to Ingolf, Ont., and began the work of connecting the monuments on the interprovincial boundary between Manitoba and Ontario with

the monuments on Dominion lands in townships 9 and 10, range 17, east of the principal meridian. Very rough country composed of deep muskegs, cut by precipitous rocky hills, was encountered. As several men, whom I had expected to engage here as labourers, refused to work on surveys in this district for even $5 per day, I was further inconvenienced, and considerable time was spent in completing this work.

When retracing the interprovincial boundary across the National Transcontinental railway-right-of-way, I noted that the railway company has erected, for the information of travellers, a signboard to mark the dividing line between Ontario and Manitoba, approximately fifty yards west of the interprovincial boundary.

The rocky country along the Ontario boundary in townships 9 and 10 is of little agricultural value. Some of the few residents of the district find land suitable for potato patches, but they live by trapping, acting as guides to summer tourists prospecting, and doing assessment work on mining claims. Several small veins of auriferous ore were noticed. The value of the mineral deposits is as yet unproven, but the numerous moose, deer, ducks and partridges found here, indicate the value of the district as a hunting ground.

A small retracement survey was made in township 6, range 9, west of the principal meridian, to effect proper closings between two old surveys. Then on October 18, I travelled to Mistatim, Sask., and completed the survey of timber berth No. 1682 in townships 45, ranges 10 and 11, west of the second meridian. No settlements other than lumber camps are found in this district.

On October 29, I began the retracement of both sides of the fifth correction line through ranges 31, 32 and 33 west of the principal meridian. Here twenty-three duplicate monuments were found and destroyed. These false monuments had caused trouble among the farmers for many years, as they did not know which were the true ones, so could not open up the road allowances.

Large discrepancies in the old surveys had caused much trouble to the settlers in developing this district, but the farmers here were found to be in a prosperous condition; although wheat farming is the principal industry, much stock is also raised.

On November 20, I travelled to Sprague, in township 1, range 14, east of the principal meridian, to make a correction survey which the settlers had petitioned for. By retracing, I found a small error in the position of one of the monuments which was therefore destroyed and a monument erected at the true corner. This district is heavily timbered and the homesteaders are making slow progress in clearing their farms. Their principal income is derived from selling firewood, raising cattle, and trapping.

The next survey consisted in correcting the posting of a small parcel of land in township 26, range 6, west of the second meridian, so that proper letters patent could be issued.

On November 26, I began retracing section lines in townships 15, ranges 25 and 26, west of the second meridian. Although several duplicate monuments had been reported, only one was found, and this was destroyed. This survey ran through some of the premier farm lands of the West. Wheat growing is to-day, as twenty years ago, the principal industry of the farmers on these celebrated Moosejaw plains. They are among the most prosperous people in the West.

The next survey consisted in retracing a large part of township 14, range 5, west of the second meridian, to determine the compensating errors in the survey arising from a deficiency of seven chains in the boundary of one section. As soon as the farmers knew that there was sufficient land in the township to give each quarter a full acreage, fifteen owners signed a petition that the survey be corrected, but three owners of land affected by the correction survey, refused to have the boundaries of their holdings altered so no resurvey was possible, under the provisions of section 57 of the Dominion Lands Surveys Act. This is to be regretted, as the township is but little developed, the

improvements to be affected by altering the monuments being of little value, while the original survey will perpetuate very crooked roads and large inequalities in the acreage of the quarter sections in the township.

On December 13, I started from the town of Winnipegosis for Steeprock lake in township 30, range 15, west of the principal meridian. As lake Winnipegosis had now frozen over, I drove across the ice to Meadow Portage and then southeast across lake Manitoba to strike the Crane river trail, which took me just four miles south of Steeprock lake. From this trail, the lake was reached by following an old surveyor's trail. An investigation of the lake showed that large errors in the original survey necessitated a new traverse of the entire lake, which was accordingly made. No settlement was found in the vicinity of the lake, except a log cabin near a gypsum prospect on the south shore.

The next survey consisted of an investigation and survey of land around Shoal lake in township 18, range 2, west of the principal meridian. This lake is drying up very fast, and its topography has changed greatly since it was first surveyed. Large tracts of land shown under water by the original survey are now converted into valuable hay meadows, which are utilized by the neighbouring settlers. The apparent cause of the low water in this large lake is the unusually small precipitation in its drainage basin during the past four years. The lake has now no visible outlet, and its water has become so alkaline as to destroy the fish, which were very plentiful during the years of high water.

After taking some observations for azimuth in township 1, range 14, east of the principal meridian, the field work was completed on January 3, 1913, and I arrived home on the 7th.

During the course of the survey, ninety-two observations for magnetic declination were taken. These observations were obtained in forty townships, where miscellaneous surveys were being made, without materially retarding the work.

Photo by G. H. Herriot, D.L.S.
Dog Teams on Cormorant Lake.

Photo by G. H. Herriot, D.L.S.
Dog Teams on Cormorant Lake.

APPENDIX No. 15.

ABSTRACT OF THE REPORT OF E. W. BERRY, D.L.S.

SUBDIVISION ALONG HUDSON BAY RAILWAY.

On June 16, 1912, I arrived at Winnipeg, where I spent a week outfitting and securing supplies.

I reached Pas on June 25, where I was delayed a week awaiting the arrival of freight. I then organized my party and proceeded with the survey of sections and the necessary outlines for three miles on each side of the Pas branch of the Canadian Northern railway, commencing at Pas and working southward. When the easterly portion of township 55, range 26, west of the principal meridian was completed, as it was found impossible to survey the east boundary of township 55, range 27, at this time, owing to floods, and the east boundaries of townships 53 and 54, ranges 26 and 27, until the extension of the fourteenth base line across ranges 27 and 26, the work here was discontinued and similar work commenced in townships 52 and 53, range 28, and townships 51 and 52, range 29, which occupied me until the end of October. At this date I returned to Pas, completed the subdivision of township 56, range 26, surveyed a parcel of land along Pasquia river in townships 55 and 56, range 26, and retraced the various blocks of Indian reserve No. 21 in this vicinity. The east boundary of township 55, range 27, was then completed.

The land traversed by the railway is spruce and tamarack muskeg, crossed by ridges covered with jackpine, poplar, and birch, but the timber generally is small. There is excellent gravel for road-making purposes on the ridges. The soil of the muskeg portions is a rich black loam covered with a foot of moss which prevents any run-off, and if it were removed and the land cleared, most of the land would probably be suitable for settlement without further drainage.

The only topographical feature of note is Pasquia river, the main stream of which rises in the Pasquia hills. The Turnberry branch, its principal tributary, crosses the railway in township 51, range 29, and joins the main river in a small lake about three miles north of the northeast corner of township 52, range 30. Both the main river and the Turnberry branch are fringed with poplar up to twelve inches and spruce up to twenty-four inches in diameter, suitable for pulpwood, lumber, and railway ties. The river is navigable for small steamers in summer, but is nearly dry at low water in winter. Stretches of land lie along its banks near its confluence with the Saskatchewan which produce a very fine crop of hay, but are flooded part of the season. There are good vegetable gardens on the Hudson's Bay company's property at Pas, and on some of the river lots. Grain has also been grown on these lots with satisfactory results, and the sectionmen at Westray and Turnberry sidings cultivate small gardens successfully. Strawberries and raspberries grow wild in great profusion along the railway track and dry ridges, rivalling the garden varieties in size.

Lumbering is the occupation of a large number of men in the district. The mills at Ruby lake, a few miles north of Hudson Bay Junction, and at Chemong, near the thirteenth base line, draw their raw material from adjacent limits. There is also a large saw and planing-mill at Pas, the logs being procured, for the most part, from limits up Carrot river.

During last summer the streets of Pas were cleared and graded, and sidewalks laid. The number of buildings in the town was doubled, and the lumbering industry, town improvements and railway construction promise to furnish employment for every available man for some years.

By the courtesy of Mr. M. H. MacLeod, general manager of the Canadian Northern Railway company, I was enabled to use a push car and velocipede for transporting my supplies and equipage along the railway, which greatly facilitated the work.

On completion of the surveys in townships 55 and 56, range 26, west of the principal meridian, at the beginning of December, I secured five teams of dogs. When these were equipped and broken to harness I proceeded across Saskatchewan river, completed the subdivision of township 57, range 26, part of townships 58, ranges 26 and 25, and the whole of township 57, range 25. I returned to Pas and paid off my party on March 17, 1913.

The land in these townships is rolling country covered with jackpine, spruce, tamarack, birch and poplar, with some extensive stretches of willow swamp. In many places, especially in the vicinity of the lakes, there are quantities of timber suitable for pulpwood and milling purposes. Reader lake, an expansion of Saskatchewan river, and Watchi lake, in township 57, range 26, are shallow and marshy. Atikameg lake averages fifteen feet in depth, and the water is clear and fresh. For some years the lake has produced over forty tons of whitefish and trout annually, and shows no sign of exhaustion. The Hudson Bay railway crosses township 57, range 25, diagonally in a northeasterly direction. The bridge across the Saskatchewan is nearly completed, and steel will probably be laid across this township early next summer. A winter trail extends from Pas to Atikameg lake, and a summer trail passes through the Indian reserve. The latter is passable as far as Watchi lake, but is in bad repair the rest of the way. Atikameg lake can also be reached by water through Moose lake and Cormorant lake.

In the swamp sections the soil is a rich black loam, which would prove very fertile if drained. Much of the dry portions of these townships is covered with jackpine and shows outcrops of limestone, indicating a soil somewhat light and shallow for farming. There are, however, several sections in township 57, range 25, timbered with small poplar which should make good agricultural land.

APPENDIX No. 16.

ABSTRACT OF THE REPORT OF G. H. BLANCHET, D.L.S.

SURVEY OF PART OF THE NINETEENTH BASE LINE WEST OF THE FOURTH MERIDIAN.

An early start for this survey was considered advisable, as much of the trail into the work ran through muskegs and over lakes. We started, therefore, as soon as the party could be reorganized after the completion of the twenty-third base line, leaving Athabaska Landing, March 22, 1912, and travelling by way of lac LaBiche and Heart lake. We reached our cache at Ipiatik lake in township 72, range 7, west of the fourth meridian on March 30, and on April 1 we moved by a new trail to a point three miles west of the northeast corner of section 36, township 72, range 6, the end of the previous line. The following day the line was picked up and range 6 started.

The height of land between Athabaska river and Hudson Bay drainage basins descends on its westerly slope in a series of ridges, broken by muskegs, and then drops in a well-defined escarpment, having a north and south course, to a fairly level country covered principally by muskegs and burned jackpine ridges. The base line left the rolling country of the height of land near the northeast corner of section 35, range 6.

In the first three miles of range 7, the line crossed a ridge of jackpine and poplar, extending from the northerly side of Ipiatik lake and running in a southeasterly direction.

Ipiatik lake, lying in the westerly part of range 7, is approached through a very wet tamarack muskeg. It is about two and a half miles across at its greatest width. The ridge forming the north shore of the lake swings off in a southwesterly direction along the course of Ipiatik river. The winter dog-trail to McMurray crosses the lake, running in a northeasterly direction. This route would not be feasible for a summer road, but could easily be opened up into a sleigh road.

The country north and northwest of Ipiatik lake, extending almost to the twentieth base line, is covered principally by muskegs, from which the drainage to the north flows into Christina river and to the south principally into LaBiche river and ultimately by both these channels into Athabaska river. This piece of country has probably small agricultural value, but, in conserving the water supply for the country north and south of it, it serves a useful purpose.

In range 9, several small muskeg streams unite in the vicinity of the base line to form Clyde river which, after making a detour to the north in ranges 10 and 11, crosses the base line on the westerly side of range 11, where it is about forty feet wide, five feet deep and flows through a willow bottom in a wide valley about one hundred feet deep, in which there are good hay lands. It continues in a southerly direction finally emptying into lac LaBiche.

In the middle of range 12, a large stream, which rises in the high land to the northwest, crosses the base line and joins Clyde river about seven miles south of the line. A good pack trail, running from lac LaBiche settlement to McMurray, follows along this river, striking off in a northeasterly direction about five miles north of the line.

In range 13 and most of 14 in the vicinity of the base line the country is principally muskeg, broken by brulé, jackpine and poplar ridges. To the north a rising sandy upland, covered with small second-growth jackpine extends for about ten miles, where the country rises more sharply into a poplar-covered highland. This extends west to Athabaska river. It reaches a maximum elevation in range 16, from where it becomes lower and broader as it approaches the river.

Two large streams in range 14 flowing from the north unite in the vicinity of the base line to form Wandering river. It follows along the base line to the middle of range 16 where it swings off to the north, returning and re-crossing in range 17. From there it strikes off in a southerly direction to LaBiche river. This river, with its tributaries, rising in the hills to the north and in the rolling poplar ridges to the south, affords drainage to the country between Clyde and Athabaska rivers.

The survey lines of the proposed Alberta and Great Waterways railway cross the base line in the western part of range 15, running in a northerly direction.

Between Wandering river and Athabaska river the country is principally muskeg, extending as far as the hills to the north and south nearly to LaBiche river.

Athabaska river crosses near the centre of range 18, having a general north and south course. The valley is about one mile in width and varies from 400 to 600 feet in depth. The river at that place flows at the rate of about three and a half miles an hour, and is navigable for boats of small draught for a considerable distance up stream and down stream as far as Grand rapids.

West of the Athabaska the country is high and slightly rolling, rising to the north towards the Pelican mountains, while to the south it becomes lower and forms an immense muskeg, extending to Calling river. Streams from the north are numerous. Those crossing in range 19 lose themselves in the muskeg, but those farther west unite in three principal streams, and empty into Calling lake. Some good hay sloughs and agricultural lands of excellent quality are to be found along these streams. Some patches of good spruce were found in range 19, along the course of the Athabaska.

Calling lake, which has an area of seventy-five to eighty square miles, was crossed by the line near the northerly end, most of range 22 and part of 23 being in the lake. Its length from northwest to southeast is about fifteen miles and its maximum width about seven miles. The country to the north and northeast drains through it into Calling river, which leaves it in its southeast corner and flows in a southerly direction into the Athabaska. Abundance of good whitefish are taken from this lake every winter and shipped to outside points by way of Athabaska Landing.

A well-pronounced ridge, for the most part heavily timbered with spruce, poplar, and birch up to thirty inches in diameter, extends along the southwesterly side of Calling lake, becoming high and rough in the vicinity of the base line in ranges 23 and 24.

Athabaska river, from its crossing in range 18, proceeding upstream, continues in a southerly course to Athabaska Landing, where it swings around to the north and approaches within three miles of the line in range 24, where it again swings off to the south. All this portion of the river is navigable. The country north of the river is composed of rolling poplar ridges, separated by strips of muskeg. Fawcett (formerly Moose) lake, in range 26 just north of the base line, is about eight miles long and varies from one-half to one mile wide. Fawcett river flows from its west end and empties into Lesser Slave river. There is a depression extending northeasterly from Fawcett lake which is chiefly muskeg; north of this the country rises towards the Pelican mountains.

APPENDIX No. 17.

ABSTRACT OF THE REPORT OF L. BRENOT, D.L.S.

SUBDIVISON SURVEYS IN THE PEACE RIVER BLOCK.

I left Ottawa for the scene of my season's operations on February 8, 1912. A few days were spent at Edmonton in organizing my party, and on the 22nd we left for Fort St. John, B.C., travelling by Athabaska Landing, Grouard, Peace River Crossing, and thence up Peace river on the ice as far as Fort St. John.

The trip from Edmonton to Fort St. John took only thirty-five days, six of which were spent at Dunvegan waiting for my provisions which had been delayed on the journey up. Mine were the first teams to take the ice trail westerly from Dunvegan. I found the ice up to Fort St. John in good condition, and experienced no trouble whatever. I believe, moreover, that it is worthy of note, that the state of the ice will permit travelling without risk until April 5 of any year. Hay and oats had to be carried from Dunvegan, as there are neither settlers nor stopping-places between there and Fort St. John.

On April 1 the subdivision of township 84, range 19, west of the sixth meridian, was commenced, and township 84, range 18, and parts of townships 83, ranges 18 and 19, were subsequently surveyed.

Fort St. John, an old Hudson's Bay trading post, established in 1830, is situated in sections 18 and 17, township 83, range 18, on the north side of Peace river. Revillon Bros. also have an outpost at this place. The Roman Catholic Church and the Church of England have mission houses in the district, but both have been closed for the past few years.

Mail service was opened last summer between Beaverlodge and Fort St. John, proving a great boon to settlers and others in that remote part of the country. The establishment of a telegraph service between the same points is expected within a couple of years and when this is done it is intended to cut a wagon road from Pouce-Coupé prairie to Fort St. John. The road from Pouce-Coupé prairie to Beaverlodge is already opened, and has been used for the last two years.

The country surrounding Fort St. John is well drained by the Peace and North Pine rivers and the Stoddart and Montagneuse creeks. The valley of Peace river has an average width of two miles, and a depth of eight hundred feet. The river itself has an average width of twenty-five chains and a depth of not less than four feet at low water in its shallowest parts. North Pine river is a stream about four chains in width; it also runs through a valley nearly eight hundred feet deep. The hills on the northerly side of both these rivers are almost prairie land and are as good for grazing as any lands in British Columbia or Alberta. Throughout the winter these hills are wind-swept and are thus kept clear of snow. In spring, therefore, the sun takes effect on the ground long before the snow has even melted on the plains. The result of this is that vegetation springs up fully two weeks earlier than elsewhere. Ranching has been carried on successfully, as stock can range all winter with practically no loss; farming conditions are very favourable, good grain has been grown, and the gardens at Fort St. John have produced all kinds of vegetables.

After completing the subdivision in the vicinity of Fort St. John, I proceeded to Hudson Hope, following the pack trail on the north side of Peace river. About fifteen miles west of Fort St. John we passed 'Jim Rose' prairie. This is a small stretch of fertile country about four miles long by two miles wide. Two squatters here had

beautiful gardens under cultivation, and I afterwards learned that they had had great success with their vegetables, as they were unhampered by summer frosts. About twelve miles west of this place, at the meeting of Peace and Halfway rivers, another small settlement was encountered. The squatters here had been industrious, and great improvements were evident. The potatoes they had grown were the largest and finest I had ever seen.

We arrived at Hudson Hope on August 6, and proceeded next day with the subdivision of parts of townships 81, ranges 25 and 26, west of the sixth meridian, completing this work on October 11. Statutory declarations were taken from thirty-two settlers squatting in these two townships.

The Hudson Hope trading post in section 18, township 81, range 25, was previously situated on the south side of Peace river, but in 1900 it was moved to the north side, opposite its old site. A short distance northeasterly the country is suitable for ranching and farming. Furthermore, it may be reasonably believed that in the near future Hudson Hope will be one of the important towns of the North; it is the head of navigation, untold mineral wealth lies untouched in this vicinity, vast coal fields have been discovered to the west and adjoining the block, and huge water-power is within easy reach.

After completing the above-mentioned work, a large raft was built and we floated down the Peace as far as Halfway river. I here surveyed the east outlines of townships 84, ranges 22 and 23, and the south boundary of township 84, range 22, all west of the sixth meridian, with the intention of subdividing the flat adjoining this meeting of the streams. Owing to the floating ice it was impossible to complete the blocks of two sections, as prescribed in the Manual, by producing the lines across the river, so I therefore closed operations for the season on November 9. Two days later we started on the homeward journey and reached Fort St. John on the 12th. Five days were then spent repairing the outfit, shoeing horses, and bringing provisions up the hill from the Fort. The journey was then resumed and it took until November 20 to get everything across North Pine river. Then two days had to be spent baling hay which had been previously cut.

During all these preparations the 'chinook' winds had been playing havoc with the snow, not leaving enough for sleighing. I made good use of the delay thus caused by starting the subdivision of township 84, range 17, and worked until November 28. A blizzard raged all the following day, and after this we were able to move on once more.

Although heavily loaded and travelling through an unbroken country, we reached Peace River Crossing, a distance of 225 miles, in twelve days. This overland trail is almost a natural road, no work beyond opening being done, yet travelling on it is much easier than on some of the roads in daily use. In ten days we accomplished the journey from Peace River Crossing to Athabaska Landing and there we boarded the train for Edmonton, where I stored my outfit and paid off my men on December 26.

APPENDIX No. 18.

ABSTRACT OF THE REPORT OF M. P. BRIDGLAND, D.L.S.

TRIANGULATION SURVEYS IN THE RAILWAY BELT OF BRITISH COLUMBIA.

Preparations for the season's survey were begun on May 3, 1912, and after making a survey of some villa lots at Banff, we left Calgary on May 9, reaching Salmon Arm in the railway belt on the 13th.

The time from May 14 till June 10 was spent on work around Salmon Arm. Two new stations were established, "Bastion" on a shoulder of the Bastion mountains five miles west of Sicamous, at an elevation of about 4,200 feet, and "Armstrong" on a burnt ridge about six miles east of Armstrong railway station, at an elevation of 5,300 feet. The latter station lies nearly a mile south of the southern limit of the railway belt at this point. In addition to the above, a third station was established on a high peak in township 18, range 13, west of the sixth meridan. Of these stations, Bastion is the only one permanently marked.

Angles were read at both ends of the Salmon Arm base and at Ida, Granite, Fly hill and Bastion. All of these stations are easily reached, and no description of the routes followed is necessary. In addition, some work was done on the Salmon Arm base. The main camp was situated near the centre of the base, and any time not otherwise utilized was spent clearing the line.

On June 11 the party moved from Salmon Arm to Malakwa, at the base of Queest mountain. A light camp was taken to timber-line just below the summit, though, owing to the large quantities of snow still remaining, considerable difficulty was experienced in finding a suitable camp ground. Then the weather changed, and for some days nothing was visible but snow, rain or fog.

On the 16th and 17th the weather cleared, the work was completed, and camp moved down to the valley. The temperature on the 17th was 103 degrees Fahrenheit in the shade, and although the descent was not difficult all members of the party were nearly exhausted on reaching the main camp.

On the 19th the main camp was moved to Revelstoke, and in the evening a light camp was brought back to Three Valley to climb Griffin mountain. In order to avoid excessive heat the climb was started that evening, and a point about 800 feet above the valley was reached. During the night a very high wind blew down a large stub which fell about two feet away from the side of the tent. This, combined with an uncomfortable bed, helped us to get an early start the next morning. At noon camp was pitched a short distance below the summit, and in the afternoon a set of angles was read. The following day smoke was so dense that further work was impossible, consequently the signal was re-erected, and the party returned to Revelstoke.

At Revelstoke Mr. McDiarmid's longitude station was located, and the angle at that point between mount Mackenzie and mount Begbie was read.

It was then decided to establish a station near the south limit of the railway belt, west of Columbia river. The party crossed the river at Wigwam, and then crossed a low divide between there and the bend of Cranberry creek. The left bank of the stream was followed till the first large stream entering from the west was reached. Camp was pitched about four miles up this stream, and the station was established on a peak about 9,000 feet above sea-level, and lying almost directly south. Angles were read, the station permanently marked and a cairn erected, although some severe thunder-storms caused a hasty retreat from the summit on more than one occasion. There is much large timber through this section, chiefly cedar

and hemlock, but much of the country is so rough that it would be a very difficult matter to get it out.

Up to this time, plans formed during the early part of the season had been fairly well carried out, but here all work was disarranged, and remained so for the rest of the season. From June 28 till July 15 all instrument work was impossible owing to rain and clouds, and the only work done was to move camp from Revelstoke to Albert Canyon, by the Canadian Pacific railway, and thence by pack-train up the north fork of Illecillewaet river to "the farm." A light camp was pitched at timber-line below "Cornice," and on July 15 an attempt was made to read angles. Work in this valley was completed on July 18.

Mount Bonney was the next station on the list, but by the time Albert Canyon was reached, smoke was so dense that work there was considered impossible. Consequently the party returned to Revelstoke and ascended Mount Mackenzie. The distances from there to the longitude station at Revelstoke and to Mount Begbie were short, but it was only with difficulty that the signals could be seen.

After the work was completed on Mount Mackenzie, the rain began again. Consequently the party started for Mount Carnes signal near the north limit of the railway belt. This is the same mountain that has been called Mount Serenity by Mr. Howard Palmer. The route taken was the same as that followed in 1910. Angles were read at the signal, the station permanently marked, and the cairn rebuilt. A set of photographs was taken at the signal and two secondary stations were occupied. The whole trip took eight days, only three of which were fine.

The remaining stations to be reached from Revelstoke were Mount Bonney, Mount Albert and Mount Begbie. These ascents were all made by the same routes as in 1911. In each case several days were lost through bad weather, and it required twenty-two days to make the three climbs.

The party then moved to Enderby and thence to Mount Mara signal in the Hunter range. Sixteen days were spent on this trip, twelve of which were stormy. Angles were read and an azimuth observation taken.

On September 11, the party started for Mabel Mountain, following the same route as in the previous year. This trip was made in five days, during which a complete set of angles was read and an azimuth observation taken. During the other four days the party travelled fifty miles by pack-train, eight miles by boat, packed camp on their backs for twelve miles, and climbed 5,500 feet.

On September 17, word was received that Mr. C. De la Condamine was waiting at Salmon Arm to commence work on the base line, and the day following the party moved over to the Arm. Angles were re-read at the ends of the base and at Mount Ida and Granite Mountain. Several attempts were made to get an azimuth at the south end of the base but, owing to clouds and excessive refraction, no satisfactory results were obtained. All triangulation work was completed on September 30.

On September 19, two men were placed at Mr. De la Condamine's disposal to assist in preparing the line. These men remained with him except for two days while assisting on Granite Mountain. The other members of the party worked on the base line while not otherwise employed. The actual measurement of the base line by the invar wire was commenced October 7 and completed November 4, during which time four measurements were made. In addition to this the base was connected with several Dominion Lands posts. A full report on the measurements of the base is being prepared by Mr. De la Condamine.

It had been intended in the early part of the season to make a rough photographic survey of the country lying betwen the north fork of Illecillewaet river and Columbia river, an exceptionally fine alpine country. Owing to bad weather, it was soon found that this would be impossible. However, photographs were taken whenever it was possible to do so without interfering with the triangulation work. Unfortunately, these were nearly always taken in cloudy or smoky weather.

Photo by O. Rolfson, D.L.S.

Norway House.

Photo by F. V. Seibert, D.L.S.

Cache on Twenty-first base line, west of the Fourth Meridian.

The season of 1912 was very unfavourable for any kind of topographical work. In addition to exceptionally wet and cloudy weather, smoke caused much trouble. Immediately after heavy rains, smoke or haze was sometimes so dense that it was almost impossible to see signals. From June 17 to 25, the weather was very hot, the temperature going as high as 103 degrees Fahrenheit in the shade at Revelstoke. From June 26 to September 8, usually the most favourable season of the year, there was rain or low clouds fifty-four days, and heavy smoke seven days, a total of sixty-one days out of seventy-six, and of the remaining fifteen hardly one day was actually clear of clouds or smoke.

MEASUREMENT OF THE SALMON ARM BASE—BY C. DE LA CONDAMINE, D.L.S.

The principle followed in the measurement was to lay down spans approximately twenty-four metres long and to then accurately measure these lengths with invar wires, the extremities of which are fitted with scales graduated in millimetres.

In order to measure a wire length or span, tripods were set over the extremities of each span, at a distance of approximately twenty-four metres; the head of each tripod bears a fine line which was placed by means of a plumb-bob over the extremity of the span. The wire was stretched between two tripods, the tension of ten kilograms being applied by two ten kilogram weights, one attached to each end of the wire by a cord which passes over a ball-bearing roller mounted on a special straining trestle. When properly placed, the graduated scales of the wire should lie against the bevelled heads of the tripods.

In December, 1910, at a temperature of fifteen degrees Centigrade, under a tension of ten kilos, the lengths of the wires were:—

No. 272.—24001.10 mm.
No. 273.—24000.94 mm.

The length at a temperature " t " is given by the formula:—

$L = 1\ (1 - 0.000\ 000\ 121t + 0.000\ 000\ 000\ 15\ t^2)$ where L is the length at t° Centigrade, 1 is the length at 0° Centigrade.

The length of the wires increases slowly in the course of time. The operation of annealing took place on February 15, 1908, and the wires were measured on December 19, 1910.

From February 15, 1908, to December 19, 1910, there are 1,038 days and from December 19, 1910, to October 6, 1912, there are 658 days, the total being 1,696 days.

According to data obtained from a study of the material of the wire

Lengthening, for 1,038 days from date of annealing 0.0094 mm.
Lengthening for 1,696 days from date of annealing 0.0112 mm.
Lengthening from December 19, 1910, to October 6, 1912 = 0.0018 mm.

This refers to a wire 1 metre long. For a wire twenty-four metres long the lengthening would be 0.0018 x 24 = 0.043 mm.

The length of the wire depends also on the temperature to which it has been subjected during the preceding two or three weeks. The mean temperature for two weeks previous to the measurement of Salmon Arm base, was + 11°.1 Centigrade. A special table gives for this temperature a lengthening of 0.009 mm.

On October 6, 1912, therefore, the lengths of the wires must be corrected by

0.043 + 0.009 = 0.052 mm.

This gives:

No. 272 = 24 001.152 mm.
No. 273 = 24 000.992 mm.

These values have been taken as giving the lengths of the wires on October 6, 1912, at fifteen degrees Centigrade, and the formula of dilatation has been applied to them.

The base was marked out by Mr. M. P. Bridgland in 1910. It lies wholly in township 20, range 10, west of the sixth meridian, and is close to the town of Salmon Arm, B.C. The northeast end of the base is in section 24, the southwest end in section 5; both ends have been connected by traverses with the nearest section posts. The base has also been connected with the northeast corners of sections 10, 9, 4 and 5, also the quarter post on the east boundary of section 5, all in township 20, range 10, and the northeast corner of section 31, township 19, range 10.

Part of the line is in cleared country and part in wooded country. The ground was generally good, though a litle soft in some parts, and swampy along the edge of Shuswap lake. In soft ground the tripods were set on stakes firmly driven into the ground in order to avoid any possible disturbance during the measurements.

The party consisted of two observers, a recorder, a leveller, and five labourers, two of whom were in charge of the straining trestles, two carrying the tripods and one setting them over the hubs.

As the line was at some distance from beaten trails, the work was carried on in such a way that transportation of instruments was entirely avoided, the wires only being carried back to camp every day. The base was divided into seven sections, each section consisting of a number of wire lengths. Starting at the southwest end of the base a section was measured in a northeasterly direction, the same section was then measured in a southwesterly direction and again in a northeasterly direction. The next section was measured three times in the same way, and so on to the northeast end of the base. The fourth measurement was made continuously from the northeast to the southwest end of the base.

The work was performed in the same way as in the measurement of the Kootenay base, with some little changes because of the employment of a recorder and a leveller who had not been engaged on the Kootenay base measurement. The line was picketed every twenty-four metres, using a steel tape as the steel wire supplied with the apparatus did not give good results.

The tripods being set over the hubs, and the wire placed in position, a reading was taken by each observer, this sufficing to give the distance between the measuring marks on the tripod heads. The wire was then disturbed slightly, in order to overcome any friction of the cords or rollers and another pair of readings taken. Five such pairs of readings were taken and if the five resulting distances derived from these readings agreed within $\frac{3}{10}$ of a millimetre they were accepted. If there was a discrepancy of more than $\frac{3}{10}$ of a millimetre between any two determinations, further readings were taken, although this was seldom necessary.

The slopes between the tripods at the different hubs were entered in a special book, the hubs being numbered to avoid confusion between the different spans. The observers changed places at mid-day each day in order to correct for personal equation.

The line is generally level, although it is broken in some places by small ridges six or seven feet high. Great pains were taken in order to obtain a slope as low as possible. In order to obtain this it was generally sufficient to set the tripods at a suitable height. In some cases, however, it was found necessary to dig trenches or to set the tripods on hubs driven into the ground. With these precautions the slope was in most cases kept below one per cent. On four or five occasions it reached five per cent, on twelve occasions six per cent, on three occasions seven per cent and once nine per cent during the four measurements. It may then be expected that the error due to inaccuracies in measuring the slope will be very small.

The slope when small was read by a special level which may be mounted on an upright gudgeon on the chaining tripods to replace a target with which each tripod

is fitted, so that the axis of the telescope when levelled should be at the same height above the measuring mark on the tripod head as the middle line of the target. The eye-piece of the level telescope is fitted with a micrometer scale, each division of which corresponds to a slope of 1 in 1,000 at a distance of twenty-four metres.

The slope between the measuring marks on the heads of two adjacent tripods was then obtained at once by setting up the telescope on one tripod and reading off the position of the middle line of the target on the next tripod, on the micrometer scale.

The micrometer scale, having been obtained by a photographic process, is not very accurate, and it is necessary to make a small correction to each reading. In order to find the correction, two methods were employed:—

Firstly.—A rod graduated in centimetres was placed at twenty-four metres from the micrometer, and the division of the rod apparently in coincidence with each division of the micrometer was read. This method is not very accurate and does not give good results.

Secondly.—Two tripods were set at a distance of twenty-four metres. The difference of elevation of the two tripods was measured with a rod and an auxilliary level. Then the slope was measured forward and backward with the micrometer, and the mean taken. The result from the level being practically correct, this comparison gave the correction to the micrometer for the divisions used. By changing the difference of elevation of the two tripods the corrections were found for as many divisions of the micrometer as seemed necessary.

Very consistent results were obtained in this way, and showed that the micrometer could be used for slopes below four per cent. Above four per cent a special levelling was done.

The levelling was checked by the following method: At the beginning and at the end of each day's work a bench-mark was established and its elevation above or below the last tripod was measured. The readings of the micrometer giving at once the tangent of the vertical angle, by adding the tangents with their proper sign and multiplying the result by 24.000 the difference of elevations between the first and the last tripod was obtained and so the difference of elevation of the two bench-marks. When running the line again this elevation was checked and the discrepancy distributed. It was so small that it would not have appreciably affected the length of the line.

At the beginning and at the end of each day's work the first and last tripods were set over a fine mark which was left in the ground until the measurements were completed. Each tripod is fitted with a plumb-bob, the point of which is on the vertical passing through the mark of the tripod's head.

The setting of the tripods is generally very tedious, especially when there is a little wind. If the wind is too strong this method is entirely unsuitable and even when the air is quite still the error in setting cannot be expected to be less than ½ millimetre. For this reason the first and the last tripods were set over the marks by means of a transit. The transit being set up a few feet from the mark and at right angles with the line, the mark was sighted and the head of the tripod was moved until it came into coincidence with the cross wires, and the span was then measured; the process was repeated four times, twice circle right and twice circle left, making a new setting of the mark on the tripod head each time; the mean of the four measurements was taken. The plum-bob was used only to put the tripod on line. Generally, the mean of the first double measurement (circle right and circle left) agreed with the other within 2/10 of a millimetre. The error in setting was then negligible.

The length of the base is not an exact number of wire lengths, the last span from hub numbered 340 to A, the southwest end of base being about fifteen metres. This span was measured by triangulation and with a steel tape in the following manner: A hub numbered 341 was established beyond the end of base A and the distances 340-A and A-341 were measured with the steel tape. The span 340-341 was then measured

with the invar wires in the usual manner, and the difference between the measurements with the steel tape and the wires was distributed in proportion to the lengths 340-A and A-341.

To obtain the length of the fractional span by triangulation, two triangles were laid down, one on each side of the base, each of them having two sides equal to twenty-four metres and the third side being the fractional span A-340. The quadrilateral thus obtained had A-340 as one of its diagonals. The eight angles and the four sides were measured and the diagonal was calculated.

The results were:—

With the steel tape.	14 923.205
By triangles	14 923.002
Difference	0.203
The mean	14 923.103

This mean has been taken as it does not appear from the measurements that one method is better than the other.

The transit used was a six-inch Watts, reading to 30″.

The weather was generally fair, though seven days were wet. When the rain was light some work was done, but it did not appear safe to work when the wires could not be kept reasonably dry, on account of the extra weight of the drops of water and of the stiffness of the cords passing over the straining trestles.

The range of temperature was from +1 to +24 degrees Centigrade, the largest correction for temperature for the whole length of the base was 7.084 mm., and the smallest correction 2.917 mm.

Taking into account the days or parts of days lost on account of bad weather, the four measurements lasted about seventeen days. The base being a little over eight kilometres this averaged a little less than two kilometres a day. It must be pointed out that the days were short and that it was often impossible to work after four o'clock.

The speed depended very much on the country, and, as a rule, where the country was open and flat the speed was almost twice as great as in wooded and rolling country. In all cases when measuring a base much better progress can be made as soon as the men become trained to the work.

The best speed was attained on October 22, when 110 spans or wire lengths were measured in seven hours and thirty minutes, the mean speed being about sixteen wire lengths or 389 metres per hour. The ground was rough at six of these spans which delayed the work considerably. The maximum speed reached during the whole measurement was twenty-seven spans (648 metres) per hour.

The rate at which this base was measured could not easily have been increased in flat and open country, but where the country was rough faster progress could have been made had eight tripods been available instead of six. With six tripods the method of procedure was as follows: While the front tripod was being centred the observers were taking their readings on the wire which was suspended between the next two tripods in the rear. The fourth tripod in the rear, that immediately behind the observers, was left untouched during these observations lest the observers should accidentally disturb their tripods before completing their readings. Meanwhile this tripod was sighted upon by the leveller, who had his level telescope mounted on the fifth tripod in the rear. The sixth tripod was being carried from the rear to the front, a distance of six spans, ready for centering.

When there was nothing to retard progress, the observers on finishing at one span moved on to the next, the front observer finding the tripod centered ready for him; the leveller moved up so as to leave but one unoccupied tripod between himself and the rear observer, the man engaged centering tripods moved ahead to prepare the next tripod for the front observer, and the man packing tripods made another trip. Should any one of these men be delayed, therefore, the whole party would be kept waiting,

whereas had eight tripods been available, the observers would always have tripods ready for them, and would suffer no delays.

In rough country the leveller had to use his auxiliary level to obtain the difference of elevation of two tripods, and this necessitated two settings of the level, as all work must be checked. A vertical circle fitted on the tripod level, graduated to give sufficiently accurate readings for slopes up to ten per cent, would obviate these delays, and the leveller would then be able to keep pace with the observers in rough as well as in level country.

In order to make a comparison of the lengths of the wires in the field, one of the spans was measured eighty times with each wire. The largest measurement with wire No. 272 was smaller than the smallest measurement with wire No. 273, the two measures differing by 11.273 mm., indicating probably that wire No. 272 was longer than its accepted length, or that wire No. 273 was shorter than its accepted length.

Comparing the two means of the eighty measurements, a difference of 0.207 mm. was found between the lengths of the two wires, wire No. 272 being the longer. The difference between their accepted lengths was 0.16 mm. It would seem, then, that there was an error of 0.05 mm. in one of the accepted lengths of the wires, and from this cause the results of the measurements of the base with the two wires should differ by 340 x 0.05=17.0 mm., wire No. 272 showing the base to be 17.0 mm. shorter than wire No. 273. The actual difference between the final results of the base measurement by the two wires is only 11.5 mm.

It must be pointed out, however, that a good comparison of the wires is impossible in the field, although from the results of the tests mentioned above, the error due to this cause would appear to be not much larger than the error of measurement.

The correction for the small difference in the intensity of the force of gravity at Salmon Arm and in France, where the tapes were standardized, was too small to appreciably affect the final results.

The mean elevation of the base above the sea-level is about 1,160 feet. Taking as radius of the earth 20,890,172 feet, the correction to reduce the base to sea-level is—453 mm.

The line was divided into seven sections. Comparing the two measurements obtained with wire 272 we have:

Section.	Spans.	Number of spans.	Discrepancy.
1	From 1 to 45	45	0·526
2	46 55	10	2·260
3	56 110	55	1·078
4	111 167	57	1·541
5	168 212	45	0·161
6	213 290	78	2·173
7	291 340	50	0·087
		340	7·826

When measuring with wire 272 the discrepancy was always in the same direction. The probable error of one measurement due to the observing errors only,

$$=0{\cdot}477\sqrt{\frac{340}{7}}\left[\frac{(0{\cdot}526)^2}{45}+\frac{(2\ 260)^2}{10}+\ldots\ldots\right]$$

$$=\pm 2.7 \text{ mm.}$$

Probable error of the mean $= \mp 1{\cdot}9$ mm.

Probable error of one span $= \mp 0{\cdot}14$ mm.

Wire 273 gave the following results:—

Section.	Spans.	Number of spans.	Discrepancy.
1	From 1 to 45	45	−0·223
2	46 55	10	+0·268
3	56 110	55	−1·562
4	111 167	57	+0·655
5	168 212	45	+2·047
6	213 290	78	−0·455
7	291 340	50	+2·963
		340	+3·693

Taking the probable errors of the measurements only we have

Probable error of one measurement $= \mp 1{\cdot}9$ mm.

Probable error of the mean $= \mp 1{\cdot}4$ mm.

Probable error of one span $= \mp 0{\cdot}10$ mm.

The results for each section are given in the following tables:—

Section.	Spans.	Wire No. 272.		Wire No. 273.	
		Forward.	Backward.	Forward.	Backward.
1	1- 45	1,080,296·754	297·280	300·109	299·886
2	46- 55	240,048·075	050·335	049·780	050·048
3	56-110	1,319,664·034	665·112	668·152	666·590
4	111-167	1,367,685·079	685·620	687·083	687·738
5	168-212	1,080,043·766	043·927	043·531	045·578
6	213-290	1,872,124·618	126·791	126·875	126·420
7	290-340	1,200,309·338	309·425	309·685	312·648
		8,160,171·664	179·490	185·215	188·908

Wire 272 (mean)	8,160,175·577 mm.
Fractional span	14,923·103
Measured length of base	8,175,098·680
Correction to sea-level	453·
Final length of base	8,174,645·7
Wire 273 (mean)	8,160,187·062 mm.
Fractional span	14,923·103
Measured length of base	8,175,110·165
Correction to sea-level	453·
Final length of base	8,174,657·2

The mean of the two lengths was accepted as the true value of the base, so that

Accepted length of base at sea-level = 8,174·6514 metres.

APPENDIX No. 19.

REPORT OF J. A. CALDER, D.L.S.

SURVEYS IN THE RAILWAY BELT OF BRITISH COLUMBIA.

E. Deville, Esq., LL.D. Ashcroft, B.C., February 12, 1913.
Surveyor General,
Ottawa, Canada.

Sir,—I have the honour to submit the following general report on my surveys in the railway belt of British Columbia, during the season of 1913.

After a few days devoted to getting my party and outfit together, I left Kamloops on June 7, and began the season's operations by making surveys required in the neighbourhood of Spence Bridge.

Lands in townships 16 and 17, ranges 24 and 25, were subdivided, and several Indian reserves and provincial lots tied in to the Dominion Lands system. Parts of the Thompson and Nicola rivers were traversed; the left bank of the former through township 16, range 25, was connected to such of the old survey monuments near the river as could be found, and these monuments were restored. Considerable difficulty was experienced in locating old corners, and many of the earlier survey monuments in the vicinity are lost.

The country in the neighbourhood of Spence Bridge appears to be particularly favourable to the production of fruit. Nearly all the varieties are grown with great success, as well as the ordinary field crops. This district, being in the "dry belt," requires irrigation, and frequently patches of good land lie unworked owing to the difficulty and prohibitive cost of getting water. Any ground in the dry belt, if not too elevated or physically unsuitable will, with water, unfailingly yield crops of all kinds in remarkable quantities and quality. In future, therefore, as land in general becomes scarcer and dearer, water will doubtless be brought to most of the lands which now lie idle for want of it.

On July 20, I moved to Canford, about twenty-eight miles up Nicola river, where I made some subdivision surveys and tied in a couple of Indian reserves.

The cultivable land in this district is well adapted for mixed farming, the elevation being about eight hundred feet higher than at Spence Bridge. I should judge that the more delicate varieties of fruit might not be a safe crop. In confirmation of this view I observed slight frosts early in August. The country generally, save for flats along Nicola river, is hilly and much of it is covered with fair timber, principally pine and fir. A saw-mill has been built on Spius creek, a couple of miles from Canford station, affording employment and a market for timber to many of the settlers.

A great deal of the best land along the Nicola valley is included in Indian reserves, and very little of it is cultivated. This is a condition general to the country, and it seems a great pity that where good land is so scarce so much of it is thus permanently idle.

Fram Canford I proceeded to Stein river to subdivide lands along its valley. This river flows from the west into the Fraser at a point about four miles above the town of Lytton. I found that for eight miles of its course the river flowed through a narrow precipitous canyon, so rough as to make it impracticable to carry on subdivision in the regular way. I accordingly located the section lines from a traverse run along the right bank of the river as far as the north boundary of section 28, township 15, range 28. Every north and south section line intersected was marked on the ground. The traverse was carefully checked by another independent traverse. From this point the canyon broadens into a valley which I subdivided for settlement as far as the centre of section 33, township 15, range 28.

In this valley, from about the east boundary of section 32, township 15, range 28, there is a narrow strip of good agricultural land as far as subdivided. This bottom land rarely exceeds a quarter of a mile in width, and is encroached upon in many places by ridges of rock debris. The sides of the valley rise abruptly in a series of

rock slides and unscalable cliffs. The low land along the river is covered with a dense jungle of red willow and other brush, interspersed with cottonwood of fair size, and occasional groves of cedar. The difficulty of opening survey lines through such profuse vegetation seriously hindered the progress of the work. The soil is generally a light sandy loam. The valley at this point is about 1,900 feet above sea-level, and appears to be free from summer frosts, the first observed being on September 19.

Owing to the thickness of the brush, it was almost impossible to see or to hunt any large game, although it was a common experience to hear a startled bear or deer crackling through the underbrush, and their tracks were everywhere abundant.

There is no trail passable for horses up Stein river, the chief obstructions being several slides formed by huge irregular masses of rock. The only present means of access to the valley by pack train is a long circuitous trail which leaves the Fraser at a point nearly twenty miles above the mouth of Stein river, and after three days' travel, leads into Stein valley in section 33, township 15, range 29, and continues up the valley for some distance. This trail can be used only for a few months in the summer as it passes over high mountain ranges and becomes blocked by snow early in the fall. It would be a costly undertaking to build a wagon road through the canyon, but a fair pack trail can be made at a reasonable expense. A road or trail of some sort must be built before settlement in the valley is practicable. The river, however, is navigable by canoes, and a road is not so immediately essential in the valley proper.

Stein river presents excellent facilities for the development of water-power. For about nine miles it is a continuous series of rapids, the fall averaging about one hundred and fifty feet per mile. An immense volume of water is discharged, but the quantity varies a great deal according to the season.

Having exhausted my supplies, I was obliged to discontinue my surveys in the valley on October 17, arriving in Lytton on the 19th.

I next made some surveys in township 15, range 26, including the traverse of both banks of Thompson river, through the east half of the township. There is but little land of value along the river in this township, as the country generally is very rocky and broken. Upon some small spots fruit is grown successfully. There are good flats on Botanie creek at an elevation of about 1,200 feet above the Thompson. The soil is a clay loam of good quality.

On November 13 I moved to Walhachin, where I was engaged until December 14 in subdividing lands in that vicinity, suitable for settlement.

There are considerable stretches of elevated open country to the south of the town, forming excellent range land. Most of it is hilly and broken up by gulches. The soil is generally a dark clay loam of fair quality, and some of the land could be tilled profitably were water for irrigation available. The greater portion of the good farming land in the immediate neighbourhood of Walhachin is controlled by English capital, much of which has been invested in the construction of reservoirs and flumes to store and convey the water for irrigation. The greater part of their water supply is obtained from Deadman river, which flows into the Thompson a few miles east of the town. Considerable areas have been planted with fruit trees, which are as yet too young to bear. The young orchards are all thriving, and give promise of abundant returns in the near future.

I finished the season's work by tying in a small Indian reserve in township 19, range 25, and on December 20, I arrived in Kamloops, where I stored my outfit and disbanded the party.

The season was very favourable, and little time was lost on account of bad weather. The fall was unusually mild and open.

I have the honour to be, Sir,

Your obedient servant,

JOHN A. CALDER, *D.L.S.*

APPENDIX No. 26.

ABSTRACT OF THE REPORT OF A. S. CAMPBELL, D.L.S.

MISCELLANEOUS SURVEYS IN THE EDMONTON DISTRICT.

My first work for the season of 1912 was the resurvey of Lake St. Ann settlement.

I secured my outfit at Edmonton, where I experienced great difficulty in procuring horses owing to the great demand for them due to the large amount of railway construction work and the rapid influx of new settlers. We succeeded, however, in securing two teams, and on May 20 set out for Lake St. Ann settlement, where we arrived on the 23rd, having travelled over a road, many parts of which are about as they were in the days of Red River carts.

The resurvey of the settlement was begun immediately, but our progress was slow as the weather was very unfavourable for survey work throughout June and July, there being only four days in the latter month without rain. Almost every day we had heavy electrical storms, many of them the most violent I have ever experienced. Our progress was also hindered by the terrible condition of the roads and by the difficulty in locating the old monuments.

At Lake St. Ann is one of the very old posts of the Hudson's Bay company, and also an old established Roman Catholic mission. The annual pilgrimage to the latter is one of the chief events of the year. There are now three or four stores in the settlement, and during the past two or three years a small amount of farming has been done in the district. The coming of the main line of the Canadian Northern railway, which passes within about three-quarters of a mile of the village, will doubtless lead to a rapid advance in settlement. Much of the land in the district is of excellent quality, though still almost all covered with fairly heavy poplar and spruce, or with brulé and brush.

Lake St. Ann itself is a fine large sheet of water, affording an abundant supply of fish, chiefly whitefish and pike, many of the former being of exceptionally large size.

Most of the original owners of lots have sold their land and moved farther back and a number of the lots have been subdivided into building lots, the idea apparently being to establish Lake St. Ann as a summer resort.

The water in the lake was exceptionally high this year, a number of the original corners being now under two feet of water, and in some places the lake has advanced a hundred feet or more on the former beach. The height of the water is due partly to the very wet season, and partly to the damming up of its outlet, Sturgeon river, which, in many places is clogged with driftwood.

The land to the east of the lake is very rolling, and bears some large poplar timber, besides a considerable amount of very good hay and pasture. This should be an excellent stock-raising district.

Having completed the resurvey of the settlement on August 8 we set out for Edmonton, arriving there on the 10th. The roads were in many places almost impassable, being soft and terribly cut up by the heavy traffic due to the hauling in of railway construction supplies.

Passing through the St. Albert district we saw many excellent stock farms. The principal crops grown appeared to be oats and timothy, the railway construction causing a great demand for these commodities.

At Edmonton we spent three or four days in finding another team, after which we set out for township 53, range 21, west of the fourth meridian, where I was instructed to retrace the boundaries of sections 30 and 31. Having finished this work we left on August 24 for township 53, range 19, following the old base line road from Edmonton to Beaverhill lake district. This road has, since the operation of the Grand Trunk Pacific, fallen into disuse and is in bad condition, numerous culverts and small bridges having been burned out. The route followed took us across the Cooking Lake forest reserve. As a result of numerous fires, there is but little sign of any forest growth, especially in the southern part of the reserve.

In township 53, range 19, I found the lines very irregular and most of the corners lost altogether, as the fires had in many places burned from one to two feet into the soil. This township is very slightly settled, except in the eastern tier of sections, many of the former settlers having left when they were shut off on the west and south by the formation of the forest reserve. The land is quite flat in the eastern third of the township; the remainder is quite rolling, and contains many small lakes and sloughs, most of which, in ordinary years, produce large quantities of hay. This year, however, we found the water very high, and hay very scarce. The soil is an excellent quality of loam for the most part, except where the fires have burned down to the clay beneath, but practically the whole township would be vastly benefited by a system of drainage. This could be easily obtained through Ross creek, which empties into Beaverhill lake, and has an abundant fall in crossing the township. The settlement of this township has doubtless been much retarded by the lack of roads, the construction of which was delayed by the municipality till the position of the road allowances could be ascertained. Owing to the height of the water, I found it advisable to leave the traversing in this township till after the freeze-up.

On the completion of the mounding we left on October 28 for township 49, range 20. As there was a large amount of traversing to be done, the resurvey of this township occupied us till December 21. The township is almost all very hilly and very little of it is suitable for anything but stock raising. A few sections in the eastern and southern parts are fairly level. The soil throughout is good heavy loam. Some parts are covered with heavy poplar, but the township is largely burnt over and grown up with heavy brush.

Miquelon lake extends across the township in a southeasterly and northwesterly direction, cutting it almost in two. There are only about a dozen settlers in the township. They have done little clearing and are almost without roads, though, during the past fall, a start was made in this direction.

Miquelon lake being without an outlet is very alkaline, and contains no fish. Deer are fairly numerous, and ducks and partridges are found in thousands, both in this township and in township 53, range 19. Around Miquelon lake and the smaller lakes and sloughs in the township several thousand muskrats were caught during the past season.

The Tofield-Calgary branch of the Grand Trunk Pacific railway passes within a couple of miles of the east boundary of the township and the Camrose-Edmonton branch of the Canadian Northern railway at a slightly greater distance from the southwest corner, but as a considerable proportion of the land in the district is held at fairly high prices, settlement is slow while free homesteads can be had elsewhere. Practically all the settlers in this township are Scandinavians.

On the completion of the work in this township we returned to Edmonton, where I paid off the men on December 23.

After storing my outfit in the warehouse at Edmonton and providing for the wintering of the horses, I, with my assistant, returned to township 53, range 19, and completed the traversing in that township, arriving back in Edmonton January 2, 1913.

APPENDIX No. 25.

REPORT OF A. V. CHASE, D.L.S.

EXAMINATION OF LANDS IN KAMLOOPS DISTRICT.

ORILLIA, ONT., February 25, 1913.

E. DEVILLE, ESQ., LL.D.,
Department of the Interior,
Ottawa, Canada.

SIR,—I have the honour to submit the following report on the examination of lands in Kamloops district, British Columbia, during the season of 1912.

I left Orillia on May 18 and proceeded at once to Kamloops where I collected my outfit. On May 27 I sent my pack train overland, and proceeded myself by train to Ashcroft, where I assembled my party and then moved north via the Cariboo road as far as Bonaparte Indian reserve No. 3. Leaving the wagon road there I moved southwesterly by pack trail to camp near the south end of McLean lake in township 21, range 25, west of the sixth meridian, where I commenced work for the season.

Township 21, range 25, is chiefly remarkable for its great area of excellent grazing land, the value of the merchantable timber being secondary, and agricultural land being entirely absent. Nearly the whole northern part of the township is good grazing land, part of it being quite open and part of it covered with open timber and poplar groves. The eastern and southeastern part of the township is mountainous, and is covered with scattered pine and fir, some of which on the northern slopes in the northeast quarter of the township is of merchantable size and quantity. In general, the eastern part, however, is rolling, hilly land the chief value of which is for grazing purposes.

The southwestern part of the township is all timbered land, rising steeply to the southwest. The timber is fir and pine, and in some places it is of merchantable size and quantity.

On June 6 I moved camp westward from McLean lake into ranges 26 and 27 and commenced the examination of the valley of Hat creek and its branches. The work was continued south to within a short distance of the south boundary of township 19. As elevations of over 4,000 feet above sea-level were encountered there in the main valley, I decided to cease operations in that locality.

This area, comprising parts of townships 19, 20 and 21, ranges 26 and 27, appears to be an ideal stretch of country for the raising of cattle and horses. To the east and west of the main creek bottom lie excellent grazing lands to the extent of seventy-five square miles and upwards, and the main creek valley contains much excellent bottom land fit for hay growing. This bottom land is not open for settlement, being already settled and cultivated, but it is mentioned here to show the possibilities of the valley as a whole. South of the south boundary of township 21 fruit growing is not a success, but potatoes were found doing fairly well in the north part of township 19, at an elevation of about 3,700 feet above sea-level. This is an instance of how favourable local conditions may be for agricultural development, in spite of considerable altitude.

The amount of land fit for agricultural development in this valley, and still open for settlement, is extremely small. There is some land in the neighbourhood of the northeast corner of township 20, range 27, consisting of good workable soil, and at an elevation suitable for potatoes and the hardier vegetables, but an elaborate scheme

of irrigation would be necessary to water it. Small areas of workable land are also found in the eastern parts of townships 20 and 21, in range 27, and in township 21 range 26, all of which require irrigation. For any lands lying to the west of Hat creek there is an abundance of water for irrigation purposes, the streams flowing eastward out of the Clear mountains, in range 27, having generally a good flow of water. Lands to the east of Hat creek, however, would have to be irrigated from that stream as the small supply of water from creeks flowing westward through range 26 is all being used at present.

Timbered lands comprise most of the east halves of townships 20 and 21, in range 26, and all of townships 20 and 21, in range 27, except a strip of land from one to two miles wide adjoining the east boundaries in range 27, and extending as far north as the centre of township 21, which is fairly open within the area examined. The northwest quarter of township 19, range 26, contains a couple of square miles of fairly open land, but otherwise the township is timbered throughout. No stretches of timber of such quantity and quality as to be notably valuable for lumbering purposes were noted in this valley. Bull pine and fir are most in evidence, and many areas were noted where trees 24 inches in diameter on the stump are fairly plentiful, but either the locality or the quantity is generally unfavourable to profitable lumbering operations. Speaking generally, the purpose to which the lands in Hat creek valley are best adapted is stock raising.

On June 25, I moved eastward through townships 19, in ranges 26 and 25, to a point in section 22, township 19, range 25, and proceeded to examine the lands adjacent to this camp in range 25.

The only agricultural land noticed in the west half of township 19, range 25, consists of about forty acres in the valley of Oregon Jack creek about three-quarters of a mile from the west boundary of the township. This area is good bottom land fit for hay-growing, but it is very difficult of access. The remainder of the west half of the township is steep, rocky, timbered mountains. The east portion of the township is a rolling hilly country and is more or less timbered throughout those lands still undisposed of, the timber, which is chiefly bull pine and fir, becoming open and scattered toward the east of the township. There is very little valuable land left unsettled, except a small flat area consisting of light sandy loam soil in the eastern part of the township, but this would need abundant irrigation for cultivation.

The undisposed of land in township 20, range 25, is nearly all timbered country on the slopes of the Cornwall hills. A small area, which offers fair grazing and which is partly covered with scattered bull pine, rises to the north from the valley of Cornwall creek. The small portion of township 19, range 24, lying west of Thompson river, contains two areas of good bench land fit for fruit growing, one in section 18 and one in section 31. The remainder of the lands in this township open for settlement are of value for grazing purposes only.

On July 1, I moved into Venables valley in township 18, range 25, and on the 6th into Twaal valley in the same township, examining lands from Thompson river westerly.

The Crown Grant lots and the Indian reserves in these valleys were evidently laid out with care to include all the agricultural land possible. The result is that, with the exception of a couple of small triangular areas in the angles of the lot boundaries, no agricultural land remains undisposed of, and the only valuable parts left are grazing and timber lands. The heights between the two valleys offer a considerable area of good grazing land, particularly on the slopes adjacent to Twaal creek, and a good class of scattered fir and pine is found on the upper slopes and on the lands adjoining the creek in the northern part of the township. West of Twaal creek are found two areas of fir timber of merchantable size and quantity, in all about two square miles in extent, the remainder of the hills being covered with a small and scrubby variety of timber in the northern part and old burn in the southern part. The lands adjoining Thompson river are generally open and very rough. A small flat bench of gravelly

soil was found in the extreme northwest part of township 18, range 25, extending into township 18, range 26, but otherwise the only land of value is grazing land. The timber on the heights west of Venables valley is small and scattered. This valley is served by a good wagon road, but Twaal valley is accessible only by pack trail.

On July 10, I moved camp to Spence Bridge, and continued the examination of lands in township 17, range 25, and in the northern parts of townships 16, ranges 24 and 25.

The most of the land in township 17, range 25, consists of steep, rocky mountains, there being two summits in the western part rising to an elevation of over 5,000 feet above sea-level. The valley of Murray creek is a steep rocky gulch which widens out to an area of gently sloping land about the west boundary of the township, but this area is so difficult of access that it is of small value. Somewhat over 100 acres of good bench land was found adjoining Murray creek in sections 10, 15 and 16, at an average elevation of 2,000 feet above sea-level. This, with small acreages in sections 4, 26 and 34, makes up the agricultural land still open for settlement in this township. These lands are accessible at present by pack trail only. The areas adjoining Thompson river, both in the westerly and southerly parts, are open and semi-open lands, of use for grazing only.

Townships 16, ranges 25 and 24, west of Nicola river, are composed mainly of a range of hills the summit of which is like the Nicoamen plateau. Lands west of Thompson river in this township are all steep rocky side-hills, timbered with small and scattered fir and pine. The Nicoamen plateau proper is a rolling summit to which the land rises from Nicola river on the east and from Thompson river on the west. A number of small benches were noted on the slope adjoining Nicola river, and similarly on the slope facing Thompson river is found an area of about 200 acres of bench land, consisting of sandy loam and dark loam soils. Much of this land is at an altitude similar to that of the Rose hill district, and should prove productive under dry culture, while 75 or 100 acres of it are somewhat lower and would require irrigation. The lands in the lower levels near the rivers are fairly open, and offer good grazing areas on their north slopes. At an altitude of 2,000 feet above sea-level timber begins to be in evidence, and the summit is fairly well covered with fir and pine of medium size.

On July 17, I moved camp from Spence Bridge westerly through townships 16 in ranges 25 and 26, and camped at the south end of Botanie lake in township 16, range 26, from which point I examined lands to the south and north in townships 16 and 17.

The chief resource of township 17, range 26, is a large area of excellent grazing land. Botanie Indian reserve No. 15 was evidently laid out with the intention of including all the valuable land in the main valley, but there is still some good grazing land east of the reserve, particularly in the south centre of the township. The land in the north centre and the northeast part is extremely rough and in general timbered. It was not examined in detail. The northwest part immediately north of the reserve is also very rough, except for a small jackpine flat of no agricultural value.

Coming southward into township 16, range 26, little land of value is found, nearly three-quarters of the area of the township being composed of rocky mountains. The valley of Botanie creek, running from north to south through the western part of the township, is very narrow and steep, and only near the south boundary is any land found fit for agricultural purposes, and this does not exceed 100 acres. This land is found to be very sandy, and the adjoining land under cultivation requires an abundance of water for irrigation. Very little valuable land is found on the hills to the east and west of the valley. A strip of timbered land about one-quarter of a mile wide follows the creek bottom, and contains a quantity of pine, fir, hemlock and spruce fit for ties.

The importance of Botanie lake as a reservoir for irrigation purposes should be noticed here. In the spring of the year a great flow of water goes to waste through Botanie creek to the south, and Skoonka creek to the east, leaving the normal flow

of the summer season much below what could be utilized for lands in Botanie creek valley and along Fraser river in township 15, range 27. By means of a dam at the south end of Botanie lake and a creek diversion to bring the waters at present draining east through Skoonka creek into the lake, a supply could be obtained sufficient to irrigate all the agricultural land in these areas.

On July 23, I moved camp south into township 15, range 26, and continued examination of the lands in that township north of Thompson river and in township 15, range 27, east of Fraser river.

A great part of township 15, range 26, is composed of the rough rocky hills of the Scarped mountains. The valley of Botanie creek, in which lies practically all of the agricultural land north of Thompson river, is fairly well settled and very little of this land remains undisposed of. Small areas of dry sandy loam bench land are found north of the Thompson in sections 8, 17, 18 and 19 which, with abundant irrigation, would be suitable for fruit-growing. The timber in this valley is unimportant.

I next moved camp to a point in Spintlum Flat Indian reserve No. 3 in township 16, range 27, and on July 31 to a point in section 30, township 17, range 27, from which main camp I completed the examination of lands east of the Fraser as far north as the boundary of the railway belt.

Only a few scattered areas of bench land fit for agricultural purposes were found east of the Fraser in townships 15 to 18, inclusive. In township 15 range 27, all the workable land east of the river sufficiently flat for cultivation is contained in sections 24 and 25. About 150 acres are workable, but this land would require abundant irrigation as the soil is sandy and porous. The remainder of the undisposed-of land in this locality is composed of gravelly cutbanks rising steeply to rocky hills. In township 16, range 26, east of the river, the hills come down to the water's edge in the southern part but recede as one goes north to about one-half mile from the river's edge, leaving a small flat in the northeast quarter of section 4, and small benches in the west half of section 16, the northwest of section 21, and the southeast quarter of section 32. None of these areas is in itself of sufficient size to provide sustenance for a settler, and they are all of small agricultural value without irrigation.

In township 17, range 27, east of the river, the hills rise steeply from points one-half to three-quarters of a mile from the river's edge, leaving small areas of bench land in sections 5 and 8, also about five acres in section 20, a considerable area adjoining but not included in lot 82 in sections 19 and 30, and a small area in section 31. These areas are all at an elevation suitable for fruit-growing, but require irrigation for successful cultivation. In the upper valley of Luluwissin creek there is considerable land in sections 22 and 23 suitable for hay-growing, but oats tried in this locality were not successful on account of the elevation, which is 3,500 feet above sea-level. A valley extends southward through section 15 containing an area of gently-sloping land fit for hay-growing. Having a southern exposure it is probable that this land would require irrigation in spite of its elevation, which is also in the neighbourhood of 3,500 feet above sea-level. In township 18, range 27, the only land of agricultural value found was in the southwest quarter of the township, and consisted of a small area adjoining lot 83 to the east in section 6, and about fifty acres some two miles up the creek valley in section 5. The remainder of the township is rough timbered hills.

In township 18, range 28, east of the Fraser, lie a number of small areas of dry sandy loam bench land suitable for fruit, if irrigated. Sections 1, 12, 13, 14, 22 and 23 contain small areas of this nature, none of which is sufficient alone for one holding and all of which need abundant irrigation. A fine area of bench land is found in section 26 at an elevation suitable for mixed farming, though a trifle too high for fruit-growing. These bench lands could be irrigated from Cinquefoil creek and a dam at its south end would turn Cinquefoil lake into an ample reservoir for the irrigation waters.

The hills to the east of the main valley of the Fraser are rough throughout and the timber on them is of little value. They are covered mostly with a small scrub variety of pine and fir, the only areas of timber having any value being in the eastern part of township 17, range 27, and in the northern part of township 18, range 28, where a very fair class of bull pine and fir was found. On August 12, I crossed Fraser river by ferry and established the main camp in section 7, township 17, range 27, from which point I proceeded to examine the lands to the west of the river from the boundary of the railway belt southward. On the 21st, I moved camp southward to section 22, township 15, range 27, and continued examination of lands to the west of the river as far south as township 14.

The lands west of the Fraser, bordering as they do on the mountains of the coast range, presented the roughest area encountered up to that time in the season's work. All the land of agricultural value found, lies within a mile of the river, the high mountains rising in some instances right from the water's edge. Fractional township 18, range 28, contains about 200 acres of excellent fruit land in sections 11, 14 and 15. This land borders on the Fraser and has a creek flowing through it which should provide abundance of water for irrigation purposes. Several old buildings are seen, and the land has every appearance of having been cultivated at one time. It is nearly all cleared and the loam soil, though slightly sandy, should prove very fertile under proper treatment. The remainder of the unsettled part of this township, west of the river, is steep rocky mountains covered mostly with timber, which is of small value on account of its inaccessible position.

Coming south into townships 17, in ranges 27 and 28, I found a number of small but fertile benches of excellent loam and sandy loam soil, generally suitable for fruit-growing, but in one or two instances more suitable for hay. These lands, with the exception of certain areas which lie as far as two miles westward, in the valleys of Intlpam and Siwhe creeks, are all situated within one mile of the river. The most southerly of these lands in this township is situated immediately west of the Fraser, partly in township 17 and partly in township 16. An area of about twenty acres of this land, although still undisposed of, is cultivated and, at the time of examination, was producing an excellent crop of beans.

Two factors may enter into the reason why these excellent lands, with abundance of water for irrigation purposes nearby, should not have been settled before now. Firstly, they are only accessible by pack trail from Lillooet, or by wagon road and ferry from Lytton. As there is only one ferry between Lytton and Lillooet, and it is privately owned, this feature places the lands in an undesirable position. Secondly, a number of these benches are at present occupied and cultivated by Indians, as for instance the bench at the south boundary of township 17, and the process of ejection is not attractive to the ordinary settler, possession being nine points of the law in the eyes of the red men.

Continuing southward through township 16, the country to the west of the river is essentially mountainous and, with the exception of those lands already laid out in Indian reserves, only two areas of agricultural land were discovered. One, already mentioned, at the north boundary of the township consists of about fifteen acres of bottom land at an elevation of 1050 feet above sea-level, in the southwest quarter of section 20. This last is at present under cultivation and is occupied by Indians.

The lands in township 15, range 27, west of the Fraser, follow the general character of lands in that locality. A strip of rolling bench land from one-half to one mile in width is found along the river between the water's edge and the mountains proper. West of this strip the mountains rise in rock formation towards summits of, in some instances, 8,000 and 9,000 feet above sea-level. Sections 28 and 33 hold a large area of workable bench land of sandy loam soil suitable for fruit-growing. About one hundred and sixty acres of workable land is contained in this area, fifty acres of which is cultivated and is producing hay. This land is evidently occupied by Indians.

Agricultural land is also found in considerable areas in the southern parts of sections 22 and 23, and the northern parts of sections 14 and 15. Some of this also is under cultivation in hay and is occupied by settlers. Other agricultural areas, about seventy-five acres in extent, were found around the northeast corner of section 2; some of these are also under cultivation in hay. The southwest quarter of section 1 contains a number of small areas of bench and bottom land of from two to five acres each, which are mostly under cultivation in hay or fruit and are evidently utilized by Indians. The land undisposed of in this township is nearly all timbered, but no areas of timber particularly valuable for lumbering purposes were noted. Bull pine and fir are scattered throughout, and show the greatest value in the south part of section 1, and in certain areas on the south side of Stein creek in the centre and west part of the township. Practically no grazing lands lie in this township.

On August 28, I returned to my old camp in township 17, range 27, west of the Fraser, to complete the examination of certain lands overlooked before on the assumption that they had been disposed of as Indian reserves. It was my intention here to move into the country surrounding the upper waters of Stein creek to make an examination of the lands there, upon which considerable comment, favourable and otherwise, was heard in the neighbourhood of Lytton. To this end I moved my outfit to Fish lake in the west part of township 17, range 28, with the intention of reaching the upper waters of Stein creek by way of a trail used by Mr. A. W. Johnson, D.L.S., about four years previously, in taking in survey supplies. At this point a continued heavy snowfall was encountered, completely obliterating the old trail which was, at best, difficult to follow. Snow continued to fall and the Indian who was to guide us over the passes failed to put in an appearance, so I decided to waste no more time in this attempt and moved my camp back to the Fraser, crossed to the east side by ferry and moved to a point in section 8, township 15, range 26, where, on September 9, I continued examination of lands eastward along the main valley, and to the south of, Thompson river.

Township 15, range 26, south of the river is a very rough area, consisting of steep mountain slopes rising from near the water's edge southward toward the summit of the Lytton mountains. A few small areas of stony bench land remain undisposed of in this locality, but they are of small importance on account of the difficulties in the way of irrigation. The chief characteristic of much of this area is its steepness and inaccessibility. It is timbered with a fair quality of pine and fir. The lands in the east part of township 15, range 26, north of the Thompson are chiefly rock hills, sparsely timbered with small and medium-sized pine.

On September 12, I moved camp to a point on Nicoamen river in township 15, range 25, and continued the examination of lands in the main valley of the Thompson, and eastward through that township. No agricultural land was found in this vicinity west of the river, the surface being steep rocky side-hill, sparsely timbered with small pine and fir. Areas south of Thompson and Nicoamen rivers show no agricultural land of importance, the whole being timbered hilly country, with some scattered areas of good pine and fir. Sections 16, 20, 21 and 22 contain areas of bench land aggregating about one hundred and twenty acres. The areas in sections 16, 20 and 21, to the extent of twenty acres, are dry sandy loam land, very suitable for fruit-growing, but they would need abundant irrigation. The lands in section 22, to the extent of about one hundred acres, lie at an elevation of 2,800 feet and upwards, and have possibilities of fertility under dry culture. They are gently rolling, of sandy loam soil, slightly stony in places, and are timbered throughout with a fair quality of pine and fir. This area is at too great an elevation to be irrigated from Nicoamen river; the lands in sections 16, 20 and 21, however, could be irrigated from it, but at considerable expense.

Considerable land in the northeastern part of the township on the Nicoamen plateau is gently rolling semi-open land with good sandy loam soil, but it is unlikely

Photo by E. Deville, D.T.S.

Looking down the Athabaska, Jasper Park. Maligne Mountains in the distance.

Photo by E. Deville, D.T.S.

Lake Patricia, Jasper Park.

that these areas have any great agricultural value on account of their inaccessibility, though their altitude, which reaches 3,500 feet above sea-level in places, may not be too great for dry culture. No areas were found under dry culture at any altitude in this locality, so no report as to its possibilities could be obtained. The remainder of the land in township 15, range 25, is rough and valueless except for grazing purposes and for scattered areas of timber of merchantable size.

On September 19, I moved camp to a point near the north boundary of township 15, range 24, about three-quarters of a mile west of Nicola river, and proceeded with the examination of the lands adjacent thereto. On September 24, I moved camp to a point in section 4, township 15, range 23, and on the 28th to a point west of Spius creek in section 35, township 13, range 23, continuing examination of lands southward up the creek valley.

A few small benches of sandy loam soil were noted adjoining Nicola river in township 16, range 24, of an aggregate area not exceeding seventy-five acres. Other small areas about one mile west of the river in the southern part of the township were noted, as well as an area of about twenty acres in extent along the south boundary of section 5, which has been fenced and cultivated. These are the only areas of agricultural land found in townships 15 and 16, west of Nicola river in range 24. Township 16, range 24, contains a large area of good grazing land west of the river, but little timber of value is seen except in the southwestern part. Continuing southward along the valley of the Nicola, the lands to the west are chiefly rough timbered hills as far south as the south boundary of township 14. In township 15, range 23, there is an aggregate area of about seventy-five acres of agricultural land undisposed of, lying in sections 8, 9 and 16, about forty acres of which is at an elevation suitable for dry culture, and the remainder of which would need irrigation. Some good areas of timber are found in townships 14 and 15, particularly along a creek valley in the west part of township 14, where a quantity of excellent bull pine and fir up to thirty inches in diameter is found. It is, however, in an almost inaccessible locality, and has small monetary value on that account.

The agricultural lands of township 13, range 23, were found to be fairly well settled, and little land of this nature remains unoccupied. Areas of good sandy loam soil suitable for cultivation, and totalling about one hundred and twenty acres, were found in sections 23, 27, 33, 34 and 36, but only one of these patches seems to be of sufficient area for a single holding. This area, containing about fifty acres of jackpine flat in section 33, is at an elevation of 3,100 feet above sea-level, and should be suitable for dry culture. The chief asset of the lands undisposed of in township 13, range 23, is the timber, much of which is excellent pine and fir up to thirty inches in diameter.

On October 7, I moved camp to a point in township 12, range 23, near the junction of Spius and Prospect creeks, and on the 15th to a point on Spius creek in the north part of township 11, range 23, and proceeded with the examination of lands in those townships.

In township 12, range 23, a considerable area of rolling and gently-sloping land was discovered which is attracting the attention of settlers. This land is chiefly in the neighbourhood of the junction of Prospect and Spius creek valleys. It lies at elevations from 3,000 to 3,500 feet above sea-level and has a fertile loam or sandy loam soil. These features suggest that the land would be suitable for dry culture, and the large timber and luxuriant undergrowth suggest great fertility. Four squatters' notices were discovered posted on this land and two more westward up the valley of Prospect creek. It is claimed that the temperatures of this area are not more severe than those in the neighbourhood of Merritt, B.C., the altitude of which is over 1,000 feet lower. I was unable, however, to find any authentic record of temperature to bear out this claim.

Another area of excellent bench land was found at the south boundary of the township and extending southward into township 11, as well as a number of small benches west of Spius creek in township 12. The soil in these areas is sandy loam and at elevations of 3,000 feet and upwards is covered with a luxuriant growth of grasses and shrubs. The main area, however, is about one hundred and fifty acres in extent and lies in the east part of section 4, township 12, range 23. Its elevation averages 2,750 feet above sea-level and it is quite free from undergrowth, being covered with open bull pine timber averaging sixteen inches in diameter. Irrigation of this area could be accomplished from Spius creek. Much good pine and fir was noted in township 12, but the timber in township 11 is small and much of the south part of the township has been burned over. Only a flying examination was made of Prospect valley west of range 23, it being found to contain only steep side-hill lands, except near the head-waters where the elevation was found to be in the neighbourhood of 4,000 feet above sea-level.

The country in the central and south part of township 11, range 23, proving rough and useless, I discontinued work in that locality, and on October 23 moved my party eastward into the valley of Coldwater river and thence southward to a camp in township 9, range 23, where I continued work in the Coldwater valley and in the neighbourhood of Murray lake.

A few acres of good land suitable for hay-growing were found at the north end of Murray lake in township 10, range 23. About fifteen acres of this is slashed and cleared, and some of it planted in hay. The elevation around Murray lake is too great for anything but hay, being 3,670 feet above sea-level. No other agricultural land was found in township 10, range 23. The township is very mountainous throughout, and presents little value of any kind. A detailed examination was not made.

Township 9, range 23, is traversed from north to south through its eastern part by the valley of Coldwater river, which is a narrow valley of bottom land flanked by steep rolling hills. Extending almost to the south boundary of the township this strip of land varies in width from ten to thirty chains, and in one place to nearly one mile, and shows agricultural value throughout. Its soil is composed chiefly of a reddish loam, the appearance of which suggests the presence of a small amount of clay. Certain areas show a gravelly subsoil, but these are not large in extent. Its elevation ranges from 3,180 feet above sea-level, in section 36, to 3,400 feet and upwards in section 2. Hay-growing should be successful throughout, and even the hardier vegetables should do well in the northern part of the valley. There is very little grazing. The value of the timber is small in the northern part of the township, there being a great deal of scrub growth west of the river. There is, however, some spruce, fir and pine fit for railway ties. Much of the land in the centre and south part of the township has been burned over and all the timber destroyed. Settlers are already moving into this valley, and with the completion of the Kettle Valley railway the development of the valley should progress favourably.

On November 2 a heavy snowfall was encountered. I accordingly discontinued work in range 23, and on the 4th moved my party towards Merritt, B.C., where I arrived the following day. On the 6th I sent my pack train, loaded light, overland to Lytton, sent my camp equipage by express and took my party there by train. At this point, not being able to obtain a wagon and team to move my outfit, I was obliged to await the arrival of my pack train, which reached Lytton on the evening of November 7. The next day I moved south to a camp in section 36, township 13, range 27, and continued the examination of lands in the main valley of the Fraser.

Practically no agricultural land of importance was found in townships 13 and 14, west of the river. Bordering, as these lands do, on the mountains of the coast range, they are composed almost entirely of steep rocky slopes rising from the water's edge. There are, however, a couple of small benches adjoining the river and immediately south of Skway-ay-nope Indian reserve No. 26. These benches, having an

aggregate area of less than twenty acres, are suitable for fruit-growing; a small portion of the area is cultivated and utilized by Indians. The hills are all timbered with small and medium-sized fir and pine.

East of the river in these townships much the same conditions exist, although the slopes are less sharp. For about three-quarters of a mile east of the river the slope is fairly gradual, but at this point the base of the mountains proper is reached. In the southern part of township 13 the mountains rise to eastward, right from the water's edge. An aggregate area of 50 acres agricultural land was found undisposed of in townships 13 and 14 east of the river. This is scattered in various small areas throughout sections 24 and 25 of townships 13, and sections 1, 23, and 25 of township 14. Most of them are occupied, and some cultivated, by Indians. The lands east of the river are all more or less timbered, but on account of the rocky formation the timber is small and scrubby.

On November 12, I moved camp southward to a point in township 12, range 26, east of the Fraser and near the northeast corner of section 19, and continued the examination of lands in this township and in that to the south.

The Fraser valley through these townships follows its general character, although the lands in township 12 have a somewhat gentler slope near the river. In township 12 the lands rise to the east and west from the water of the river, leaving small areas of bench land from one to one and a half miles from the river, from which points the mountains rise steeply through rocky formation. The bench lands in township 12, range 26, to the east of the river, are chiefly small areas of loam and sandy loam soil, at present occupied and in some instances cultivated by Indians, notably in sections 3, 4, 9, 10, 16 and 20. An aggregate area of over three hundred acres in these six sections is agricultural land, all of which is less than 1,600 feet above sea-level. It is claimed by the occupants of these lands that local conditions of temperature render them unfit for fruit-growing in spite of the low altitude. This condition is not consistent with conditions to the west of the river, where a flourishing orchard was found at an elevation only slightly less than that of the greater part of these lands. In my opinion these lands could be utilized for almost any kind of agricultural development. A long narrow bench runs parallel to the river through sections 29 and 31 and contains about seventy-five acres of land more adapted to fruit-growing than to other agriculture. Its soil is a deep sandy loam, with a large amount of surface stones.

West of the Fraser, in township 12, range 26, the lands suitable for agricultural development are fairly well taken up. There remains about one hundred acres of good bench land in section 5, about five acres of which is cleared and the remainder covered with a rather dense growth of small fir, birch and alder. Small benches, to the extent of about forty acres were also noted in sections 8 and 17; all of these are at an elevation suitable for fruit-growing. The timber in this township is of small value except in the area included in timber berth No. 428 and in sections 3 and 9, east of the river, where some good tie timber was seen.

In township 11, range 26, east of the river, only a few small benches adjoining the river were found; the most notable of these lie parallel to the river through section 14, adjoining Boston Bar Indian reserve No. 4. Old buildings there showed past occupation, and in the land south of the reserve some recent improvements have been made. This land shows good deep sandy loam soil and should produce a very good fruit crop.

West of the river a number of benches, having an aggregate area of about two hundred acres, were noted in sections 11, 14, 15, 32 and 33. This land is generally of sandy loam soil with some areas slightly gravelly and stony and all at an elevation suitable for fruit-growing. Portions of this area near the river are open, but most of the area is timbered with a dense growth of young fir, birch and alder. The remainder of the township is timbered throughout, but no timber of merchantable value was noted, it being of a small and scrub variety on account of the rock formation.

At this point, on account of the difficulty in obtaining feed for the horses, and the small amount of land still to be examined in order to close on lands examined by Mr. G. A. Bennett, D.L.S., in 1910, I decided to disband my party and complete the work without their assistance. Having therefore completed as much as could be satisfactorily done from my camp in township 12, range 26, I moved into Lytton on November 22 and, when I had disposed of my outfit, disbanded my party. I then went to North Bend by train and made an examination of the lands east of the Fraser in townships 9 and 10, range 26, and part of the township west of the river.

After a preliminary examination of townships 9 and 10 east of the river, I was convinced that a detailed examination was unnecessary. The valley of the Fraser in these townships presents a much rougher area than that met with heretofore in this season's work. Throughout almost the entire length of the valley in these townships the steep rocky mountainous slopes to the east of the river rise from the water's edge. The only agricultural land noticed has already been disposed of. The lands are timbered throughout, but the timber is similar to the general class on these mountains, being small and scrubby.

Throughout the work of this season many unsurveyed lands were examined and it was necessary to tie these lands to the Dominion system. This was done almost entirely by stadia traverse, which method was found most satisfactory, both as regards speed of operation and accuracy. The elevations determined in the work are all given in feet above sea-level. These were computed from the readings of aneroid barometers which were compared each day with a large stationary aneroid kept in camp. Readings were taken on the camp aneroid every two hours and, by interpolation, practically simultaneous readings were obtained, one aneroid, the stationary, being read at a point whose elevation was known, and another at the point whose elevation was desired, or vice versa. In this way, by a system of back-sights and fore-sights, actual elevations above sea-level were carried throughout the work, it being the rule to first obtain the elevation of the stationary aneroid at camp and compute the other elevations from this known point. Besides the elevations of various points along the main line of the Canadian Pacific railway, which were furnished me with my instructions, the elevations of certain bench-marks determined in the survey of the Canadian Northern Pacific railway in the Fraser valley, of the Canadian Pacific railway in the Nicola valley, and of the Kettle Valley railway in the Coldwater valley in range 23, were used as bases from which to compute elevations of other points.

On November 27, having completed work for the season I returned to Lytton and when I had completed my arrangements there, went to Kamloops, where I spent parts of two days in the Dominion Lands office checking over areas disposed of and not shown on the district plans. I left Kamloops on November 29 for Orillia, Ont., where I arrived on December 4.

I have the honour to be, Sir,
Your obedient servant,

A. V. CHASE, D.L.S.

APPENDIX No. 22.

REPORT OF G. C. COWPER, D.L.S.

RESURVEYS IN SOUTHERN ALBERTA.

WELLAND, ONT., February 7, 1913.

E. DEVILLE, ESQ., LL.D.,
Surveyor General,
Ottawa, Canada.

SIR, I have the honour to submit the following report on miscellaneous surveys and resurveys carried on in southern Alberta last season.

I left Welland on May 3, and reached Medicine Hat with my horses and outfit on the 14th of that month. After spending a few days in Medicine Hat in organizing my party, getting the horses shod and wagons repaired, I left on the 21st for township 19, range 4, west of the fourth meridian, following the main trail from Medicine Hat to the forks of Red Deer river.

For the first sixteen miles from Medicine Hat the country along the trail is very well settled, and the farmers, who go in mostly for mixed farming, appear to be quite prosperous. Farther north the land is more or less hilly and sandy, and has not as yet been taken up. After leaving the settled country, water along the trail is very scarce. My work here was to make a survey of townships 10, ranges 3 and 4, west of the fourth meridian. This was completed on July 8.

My next work was to make a retracement survey of townships 17 and 18, range 3, and a resurvey of township 17, range 4. When these townships were originally subdivided, river lots were laid out along South Saskatchewan river. These lots were afterwards done away with, and the monuments marking them destroyed, but the section lines through the river lots were not run. My work in townships 17 and 18, range 3, was to retrace the lines already run, and to survey the lines which had not previously been run.

To get from township 19, range 3, to township 17, range 3, I found it necessary to move my party eighty miles around by Medicine Hat, as I was unable to find a suitable place to ford the river. The trail from Medicine Hat to township 17, range 3, is the main trail north on the east side of the river. The country is better settled on this side than on the west side, and the land is pretty well taken up as far as township 17.

I commenced the survey of townships 17 and 18, range 3, on July 15, and completed it on August 20. From there we moved into township 17, range 4, the survey of which occupied the party until September 10. This completed my surveys in this district.

These townships, with the exception of township 19, range 3, are admirably suited for ranching, which is the main occupation of the settlers. Townships 17 and 19, range 4, are practically all under lease for ranching purposes. Township 19, range 3, with the exception of a few sections on the south side of the river, is practically all sand hills, and willow and rose-bush scrub, with a few scattered poplar trees.

Townships 17 and 18, range 3, have been under leases for ranching, but as the leases are expiring the homesteaders are taking up the land. While I was camped in township 17, range 3, six quarter-sections were filed on in this township. The soil being a mixed sandy and clay loam is well suited for farming, but the rainfall is light.

It is commonly believed, however, that as the land becomes broken the rain increases, and if this be the case the homesteaders here should meet with success, especially if they go in for mixed farming. The country is all prairie, and, with the exception of a little scrub in the coulées, and a few trees along the river, there is no wood.

The Saskatchewan, which cuts all the townships we worked in with the exception of township 19, range 4, has high cut banks from four to five hundred feet in depth, with deep coulées running back from the river. The current varies from about four to eight miles an hour, and in some of the rapids exceeds even this. During the past season a number of settlers taking up land at the forks of Red Deer and Saskatchewan rivers used the river to float down their lumber and supplies from Medicine Hat.

A large number of rattlesnakes frequent the shores of the river, and during the time we were working there my party killed over three hundred of them.

My next work was to survey some lines in townships 21 and 22, range 10, west of the fourth meridian, which had not been previously run owing to the fact that river lots had been laid out along Red Deer river. I took the party back to Medicine Hat and followed the Canadian Pacific railway as far as Carlstadt, from which place we turned north, reaching township 21, range 10, on September 17.

Owing to a number of homesteaders being absent I could not get them to agree to my erecting monuments which would affect their boundaries, and consequently was unable to erect a number of monuments marking my survey. I therefore left blank petitions for resurveys in both townships.

These townships are fairly well settled, some of the settlers having lived there four or five years. The crops on the whole were very good, flax, running eighteen and twenty bushels to the acre, while potatoes and other vegetables did very well. On the north side of the river the settlers have great difficulty in getting water, and the majority of them have to haul all the water they use from the river. The Government drilled a well over 300 feet in depth but the water found was not very good.

After completing these surveys, I returned to Medicine Hat, disbanded my party on October 4, and put my horses out for winter. One of my assistants went with Mr. Deans on inspection work in Manitoba, and with the other I started out to do miscellaneous surveys.

My first work was to investigate a lake in section 3, township 10, range 12, west of the fourth meridian. I found that it had dried up and that the whole section was suitable for farming purposes.

My next work was the survey of an island in Beaver lake in township 51, range 17, which I completed on October 22. I then went to Heath to investigate Barnes lake in section 1, township 44, range 5. I found it to be incorrectly shown on the township plan, but owing to it being surrounded with thick brush and scrub, and being unable to hire any axemen, I left the traverse until the lake froze over. I then returned to Edmonton and retraced that portion of section 24, township 53, range 27 which was formerly part of the Michel Calahoo Indian reserve. I made this survey on October 31 and next day drove to section 32, township 51, range 26, and made a survey of a lake in this section on November 2.

I then investigated Sullivan lake in section 2, township 36, range 14, and finding that there was some dry land in the section I made the necessary surveys on November 6.

I next went to township 40, range 5, and surveyed a lake in section 18 on November 9. Returning to Heath I found Barnes lake frozen over and traversed it on November 12, leaving for Edmonton the next day.

Here I found instructions to complete some traverses in township 60, range 1, and townships 64, ranges 4, 10 and 12, west of the fourth meridian.

After securing a small camp outfit, we left Edmonton on November 18 for Lloydminster, and from there we drove to Onion lake, where we secured a team and half-breed driver. We followed the main Cold lake trail as far as Angling lake, where

we turned off to do the work in township 60, range 1. From there we had to pack for six miles to get to the work, which we completed on November 27. We then returned to Angling lake and reached the south end of Cold lake on November 29. From this place we found a trail to township 64, range 4, and finished the survey there on December 1.

To get from township 64, range 4, to township 64, range 10, I found it necessary to return to Cold Lake mission and follow the St. Paul trail as far as Rife, from which place we turned north. There is, no doubt, a direct trail fom Cold lake to lac La Biche, but owing to the lateness of the season and the small amount of feed for the horses which we were able to carry, it was imperative that we keep as much as possible to settled districts. We reached township 64, range 10, on December 7, made the required survey that day, and the survey in township 64, range 12, on December 9. We then started back for Edmonton and reached St. Paul de Metis, a busy town of about three hundred people, on December 12. I sent the team and teamster back to Onion lake and, with my assistant, took the stage to Vegreville, arriving at Edmonton on December 14.

The country north of Saskatchewan river is very well settled, and I was surprised at the prosperity of the farmers, some of whom, although over 100 miles from the railroad, have good buildings and all the conveniences of a farmhouse in Ontario. With the completion of the railroad from Battleford to Edmonton this country will make rapid progress.

I closed operations for the season at Edmonton and reached Welland on December 23.

I have the honour to be, Sir,

Your obedient servant,

G. C. COWPER, D.L.S.

APPENDIX No. 23.

ABSTRACT OF THE REPORT OF W. J. DEANS, D.L.S.

INSPECTION AND MISCELLANEOUS SURVEYS IN MANITOBA AND SASKATCHEWAN.

I left my home on May 28 for Prince Albert, where I intended to organize my party. Owing to the lateness of the season and the scarcity of labour it was June 5 before I left there for Shellbrook, where I procured my horses and outfit. On June 9, I started for contract No. 11 of 1911 in the vicinity of Boutin, where my inspection work was to begin.

The country between Shellbrook and Boutin is well adapted for agriculture and is being rapidly taken up by a good class of settlers. There are, however, many homesteads in this district which are still available.

On June 13, after a pleasant trip over a good trail, I arrived in township 54, range 8, west of the third meridian, which forms part of contract No. 11 of 1911.

The land comprising this township and townships 53 and 55 is generally adapted for mixed farming purposes. The soil is good and there is an abundance of hay in the marshes, and good water in the numerous lakes, while suitable timber for building purposes may be obtained in many places. The Big River branch of the Canadian Northern railway is located a short distance east, which makes access to the markets easy and certain at all seasons of the year.

My next work was to correct the road allowance between townships 50 and 51, range 12, west of the third meridian. On June 19 I started for this place over the Green Lake trail, which I found in good condition. I travelled on this trail about thirty miles, then forded Big river and passed down the west side of Witchekan lake. There is an extensive area of good agricultural land west of the lake, mostly open prairie with light poplar scrub in places. I did not see any settlers, although this land is open for homesteading. About half way down the lake on the west side we came across numerous wicker and rustic structures which had been erected recently by the Indians.

On June 21, I arrived in township 51, range 12 and next day started to resurvey both sides of the road allowance between townships 50 and 51, which had been left too wide when the townships were subdivided. While on this work we had some heavy gales which blew down trees in all directions, and also our tents. These winds were followed by cold rains which made our progress slow, so that work which could have been completed in a week under ordinary weather conditions required twice that time.

I also made some other corrections in this vicinity, and on July 14 started for Shellbrook. On my way I branched off at Mistowasis to investigate the marking of the post at the northeast corner of section 12, township 49, range 9, west of the third meridian. I found that this post had been correctly marked.

There is quite an extensive unsettled country west of Mistowasis which is open for homesteading. The country is somewhat broken with ridges and sloughs and covered more or less with small poplar and willow, but the soil is a good black loam. Pea-vine and grass grow in great luxuriance throughout the district and the sloughs are full of good water, which makes this a splendid country for mixed farming and cattle raising.

On July 22, I arrived at Shellbrook and on the 24th shipped my outfit by the Canadian Northern railway to Tisdale, at which place it arrived on July 31.

On August 1, I started for Arborfield from which place I sent in a portion of my party with pack-horses to inspect the northerly part of contract No. 7 of 1911. The country between Arborfield and Tisdale is fairly well settled, but there are still quite a number of homesteads open for entry. The soil generally is a black loam with clay or sand subsoil and produces crops of wheat, barley and oats which could not be excelled anywhere. There is an abundance of wood suitable for fuel, and plenty of timber for building purposes. The trails and roads are good. The settlers have good buildings, and schools and churches are within easy reach of all. The water in the numerous streams is good, and grass and wild pea-vine grow luxuriantly. Horses, cattle, sheep and hogs all thrive in this district. Wild fruit, such as raspberries, grow in great profusion. We passed a great many berry pickers on the road all laden with large quantities of berries. A settler coming to this part of Saskatchewan who possesses ordinary intelligence and industry would have a competence in a few years, for nature has certainly distributed her bounties with a generous hand. There are a great many homesteads available east of Arborfield and a number of settlers were engaged cutting a trail into township 48, range 10, west of the second meridian, so that now these new lands are easily accessible.

On August 8 I started for Tisdale, arriving there on the following day. From there I shipped my outfit to Mistatim in order to continue my inspection of contract No. 7 of 1911. Owing to the great rainfall in July and August, the country around Mistatim was very wet, and I found it a most difficult undertaking to get into contract No. 7, even with pack horses. I finally cut a trail to the northeast corner of township 45, range 10, from which point I conducted most of my inspection.

The surface of the land in the southerly part of contract No. 7, *i.e.*, in township 46 and the northerly part of townships 45, ranges 9 and 10, and around Mistatim is gently rolling and covered with a thick growth of poplar and small birch, with patches of spruce suitable for sawlogs. There are many sloughs, marshes and small lakes throughout the district. Grass and peavine grow very rank. This will be a good mixed farming country when cleared and drained. There is a saw-mill at Mistatim which runs during the summer months and employs a large number of men. This company was unable to obtain sufficient help last season, although they offered $2.50 per day for labourers. There are no settlers around Mistatim engaged in farming, although there are many homesteads which would be productive with little labour, and as all produce has to be brought in by train a settler engaged in farming would be sure of a good market for any produce.

On August 23, I shipped the outfit by Canadian Northern railway to Portage la Prairie, where it was decided to leave it temporarily while I proceeded with the inspection of contract No. 19 of 1909 in townships 7 and 8, ranges 16 and 17, east of the principal meridian. I accordingly left for Kenora, where I hired a gasolene launch and went up to Indian bay, the extreme westerly part of Shoal lake.

I arrived at this contract on August 31, and on September 2 started the inspection. The greater part of the contract consists of tamarack muskegs, willow swamps and rocky ridges covered with scrub jackpine. The heavy rains of July, August and September filled the muskegs to overflowing, so that the inspection of the contract was very difficult. In addition to the rain we had three days of snow and sleet near the end of September, all of which interfered with the progress of our work. I also surveyed timber berth No. 1903, which is situated in this contract.

On September 27, I started for Kenora with my outfit loaded on a gasolene launch and barge. The lake got so rough that we were in danger of being swamped, so we had to put into an island and unload the men and outfit. Having done this, I started with two men in the launch, and, after a stormy time, reached Kenora that night. The next day I sent out a launch and brought the outfit and party in.

My next work was around Brereton lake. Certain lands in this district were urgently required, and before they could be dealt with it was necessary to have a

survey made and confirmed. I also had to inspect contract No. 1 of 1911 and contract No. 24 of 1908 in this vicinity. The lands throughout these two contracts consist largely of tamarack muskegs, willow swamps and rocky ridges. In the westerly part of contract No. 24 there is some land suitable for farming purposes and in many places throughout both contracts there are small patches which would produce potatoes and garden vegetables in favourable seasons. Brereton lake is a fine sheet of good pure water about three and a half miles long by one and three-quarter miles wide, situated about seventy miles east of Winnipeg, and easily reached by the Grand Trunk Pacific railway. In many places around the lake the beach is sand, and there are seventeen islands of various sizes and shapes. Maskinonge are quite plentiful in the waters of the lake, and attain a great size. Moose and elk were seen nearly every day while we were engaged in this vicinity. This lake will no doubt become a favourite summer resort for the people of Winnipeg. The work around Brereton lake required a long time to complete on account of the wet nature of the country and the exceptionally wet season. In November we had sufficient frost to freeze the muskegs and marshes a little but not sufficient to carry the weight of a man. Breaking through the ice in a muskeg for the greater part of the day makes the carrying out of a survey very slow.

On December 14, I started with a portion of my party for Portage la Prairie, leaving my assistant and the remainder of the party to finish some work near Ophir. I shipped my outfit which had been previously left at Portage la Prairie to Glenella, where I was joined by my assistant and the remainder of my party. Here I procured two sleighs and some supplies and started north to inspect contract No. 5 of 1912, which lies northeast of lake Manitoba. This contract consisted of townships 21, ranges 11, 12 and 13, and townships 22, ranges 12 and 13, west of the principal meridian. These townships formerly formed a part of the Manitoba West Forest reserve. The land is gently-rolling with ridges running in a northwesterly direction, and contains many hay marshes. In many places there are quite large open tracts of prairie, but generally the land is covered with a thick growth of small poplar and willow; in the northerly part there are a number of fairly large bluffs of spruce from eight to twenty-four inches in diameter. The soil is good, and water of the best quality is easily obtained by digging a few feet. It is expected that a branch of the Canadian Northern railway will soon be extended through this district This would make the transportation of crops and produce to markets easy.

My next work was to examine a part of contract No. 11 of 1912, consisting of townships 23, ranges 12 and 13. The land in these two townships is much the same as in contract No. 5.

On January 5, 1913, I started with my outfit for contract No. 12 of 1912. I stayed for a day at Ste. Rose du Lac to procure supplies, and on January 7 started out for Toutes Aides, a post office on lake Manitoba. The travelling was slow on account of deep snow and very cold weather. There is an extensive country north of Ste. Rose du Lac between lake Manitoba and Dauphin lake, in which there are many homesteads available for settlers. The land is rolling and covered with willow and poplar scrub, with many patches of open prairie and hay marshes. In some places there are large bluffs of poplar suitable for building purposes. It is expected that a railway will soon run through this part. On January 10 we passed a number of fishermen engaged in their work. One of these men told me that he had taken over three hundred dollars' worth of fish in less than a month.

On January 11 I arrived on contract No. 12 and commenced my inspection on the 13th. Afterwards I inspected the remainder of contract No. 11 of 1912 and contract No. 10 of 1912.

These three contracts adjoin the northerly shore of lake Manitoba and stretch from Waterhen river to Portage bay. The whole district is generally level and covered with willow and small poplar, with patches of spruce, tamarack and jackpine,

which in places is large enough for sawlogs. There is an abundance of hay throughout the district, and the soil is good. Fish are plentiful in the lake and can be disposed of at a good price. Moose and elk are numerous. This district offers great inducements to the settler who wishes to engage in mixed farming or cattle raising.

On February 5, having stocked up with supplies and feed for the horses at Fairford, I started for contract No. 9 of 1912 and completed the inspection on the 12th. It was now necessary for me to cut about twelve miles of trail in order to inspect contract No. 8 of 1912, and as the weather was very stormy and the snow deep, I was somewhat delayed and did not arrive on this contract until February 19. I completed the inspection on the 22nd.

The country east of lake St. Martin for a distance of three or four miles is level, with many marshes and tamarack muskegs. Thence it ascends in flat ridges covered with jackpine. This part of the country was burnt over a few years ago, so that in many places there are large tracts of land on which the jackpine is from two to four feet in height. There are, however, many fine groves of jackpine from eight to twelve inches in diameter which escaped the fire. In township 29, rang 5, west of the principal meridian, there is some land suitable for mixed farming, but the chief asset of this district at present is the jackpine and tamarack, which would make cordwood and ties.

In order to reach contract No. 7 of 1912 it was necessary for me to cut twelve miles of trail, a good deal of it through windfall. This, with deep snow, impeded my progress so that it was not until February 27 that I reached this work. I travelled through this contract easterly a distance of twelve miles cutting trail the greater part of the distance. I finished the inspection of this contract on March 15, after which I inspected contract No. 6 of 1912.

The land in townships 28, range 3, 4 and 5, west of the principal meridian, is generally gently rolling and covered in the northerly part with a thick growth of poplar and spruce, which in some places is large enough for sawlogs. The southerly part of township 28, range 3, is very wet. There are a number of muskegs on both sides of Mantagao river, a small stream about fifty links wide, which flows northerly into lake Winnipeg. There is some good farming land in township 28, range 4. If Mantagao river was opened up a little, much of the adjoining land would make splendid hay meadows, on which hundreds of cattle could be raised.

On March 13, I moved camp to section 33, township 27, range 3, and corrected the marking on the monument at the northeast corner of the section. I had intended to return to Moosehorn, but owing to the depth of the snow and the scarcity of horse feed I thought it advisable to come out to the nearest settlement, where I would have good trails and plenty of hay and oats for the horses. I therefore came out to Fisher River settlement and thence to Arborg, the terminus of the Arborg branch of the Canadian Pacific railway. From there I proceeded to Portage la Prairie, where I stored my outfit.

The season was not a good one for field work. In July, August and September the rainfall was excessive so that progress was very slow, and as all the muskegs and marshes were full of water, wading through them in October and November was cold work. December, January, February and March were, however, very good months for working; the weather although rough did not seem to be excessively cold or stormy. I paid my party off on March 19 and arrived in Brandon on the 22nd, having been nearly ten months in the field.

APPENDIX No. 24.

ABSTRACT OF THE REPORT OF S. L. EVANS, D.L.S.

MISCELLANEOUS SURVEYS IN SOUTHERN SASKATCHEWAN AND ALBERTA.

My first work for the season of 1912 was in the Maple creek district where I made retracement surveys of township 8, range 22, townships 6, ranges 24, 25 and 26, township 7, range 28; and part of township 6, range 27; all west of the third meridian.

These townships lie to the south of Cypress hills, a range having an altitude of about 3,000 feet above sea-level.

At present, ranching is the chief industry of the district and some large and successful ranches are located on Whitemud river which runs through some of these townships. A few scattered quarters have also been taken up by homesteaders. To the south of these townships there are large settlements and, according to reports, the settlers are making a success of farming.

The soil generally is of a gravelly nature and this, coupled with the dry climate in this district, would seem to indicate that dry farming operations would have to be practised by homesteaders wishing to make a success of farming. I am, however, of the opinion that the district is best adapted for ranching purposes. Cattle and horses thrive well the year round on the native short sweet grasses.

Cypress lake, which is about six miles long by two miles wide, and the head of Frenchman river, is located in township 6, range 26. I believe this lake has been considered by the Irrigation Department as being suitable for a large reservoir for irrigation to serve the country lying to the south and east of the lake. This district would no doubt be much improved for agricultural purposes were this irrigation scheme carried out.

Along the bank of Frenchman river, large outcrops of a white clay appear. This clay is said to be excellent for pottery purposes and awaits development along this line.

Outcrops of lignite coal were seen on the north branch of Battle creek in township 7, range 28. There is very little bush in any of these townships, and the coal is thus a great boon to the homesteaders.

A great many antelope roam in this district, as many as thirty in a drove being seen by my party.

The Weyburn-Lethbridge branch of the Canadian Pacific railway is being built through this district. This will no doubt add a further incentive to agriculture.

In July the work in Maple creek district was suspended for a time and we proceeded to township 13, range 14, west of the third meridian, where some retracement surveys were required. We drove across country, a distance of about one hundred miles, following good roads and trails for most of the way. This township is well settled, mostly by Germans, and mixed farming is being carried on quite successfully. It may be noted that the rainfall is heavier in the districts east of the Maple creek country.

Towards the end of September I shipped my outfit to High River settlement for the foot-hill work, and on September 28 started by wagon for the northeast corner of township 20, range 5, west of the fifth meridian. This was readily reached by road to Okotoks, thence by trail up the north branch of Sheep river.

After running the east boundary of township 20, range 5, I proceeded to the northeast corner of township 20, range 6. To establish a camp near our work here we had to pack our tents and outfit ourselves.

The country is very rough and broken and lies close in to the Rockies . The north-east corner of this township is at an elevation of nearly 7,000 feet.

The survey of the east boundary of township 19, range 5, and the subdivision in township 19, range 4, was carried on from camps located on the south branch of Sheep river.

Some good seams of coal outcrop on the banks of both forks of this river.

The country is too broken and rough and is at too high an elevation for agricultural purposes. For the most part the surface is covered with second-growth jack-pine and small spruce.

The streams are very swift and no doubt offer possibilities in the way of future power development.

We had a considerable fall of snow during November, and owing to scarcity of horse feed we left on November 20 for High River settlement, where the party was disbanded.

I then proceeded with my assistant to Macleod for the traverse of Oldman river in townships 9, ranges 25 and 26, west of the fourth meridian. This was completed on December 17, and on the following day I left for home.

APPENDIX No. 25.

ABSTRACT OF THE REPORT OF J. A. FLETCHER, D.L.S.

OBSERVATIONS FOR LATITUDE.

Before commencing the season's field work I went to Toronto, on April 23, 1912, to make a determination of the constants of dip circle, T.S. No. 62. I was required to observe for magnetic dip and total force wherever possible during the season, and it was necessary to determine the constants of the statical needle both before and after the season's work. These constants were determined with the required precision by April 30, and I left that evening for the West.

I arrived at Salmon Arm, B.C., on May 4, and I found the weather at that time of the year to be very delightful. Rain falls in this vicinity in sufficient quantity to obviate irrigation, while the extreme moisture of the coast is escaped. The settlers here seem quite prosperous, the chief industries being fruit, hay and vegetable growing and dairy farming. Fruit, such as apples, pears, plums, peaches, cherries and the small fruits all mature well. Considerable cloudy weather was met with here and the observation was delayed somewhat on that account, but by June 3 it was completed.

I proceeded next to township 61 on the second meridian. I went by way of Regina, Prince Albert and Hudson Bay Junction to Pas, where I arrived on June 11. The same evening I left for Cumberland on a steam tug and scow owned by Captain Ross, who makes freighting trips up and down Saskatchewan river all summer. In this instance he had been engaged by the Hudson's Bay company to tow four of their York boats across Namew lake on their way to Pelican narrows and Churchill river. I accompanied them up the lake as far as the point projecting from the western shore in township 60. From there I proceeded to the point of observation on the second meridian in township 61, using a twenty-foot freight canoe kindly loaned me by Mr. E. M. Joyal.

On arrival at the point of observation, a space was cleared of trees and rubbish and the foundation prepared for the telescope. Some trouble was experienced in getting a good set up as frost almost a foot thick was still in the ground. By digging three holes for the tripod through the frost and packing the holes with beach sand, a very stable foundation was secured. The temperature while here was the highest experienced all summer, the mean of the temperature while observing at night being 58°. Several jackfish and pickerel were caught here with a line.

This observation was completed by June 28, and the return to Pas was made by canoe all the way, travelling on the lake only in fair weather. We entered Tearing river at eleven o'clock, and arrived at the Saskatchewan by four. Tearing river is very swift in some places, and only in high water does the steamboat use this channel. We reached Pas on July 4.

I proceeded next to Prince Albert and hired a wagon, team and teamster to take my outfit to township 57, on the third meridian. The trail which, on account of the wet season, was in some places difficult to travel, passes through a heavy clay loam for about two miles after leaving Prince Albert, and then crosses country generally with light or sandy soil. In the sandy districts the rain improves the travelling as the sand, when wet, is firm. While going north, Red Deer river was in its normal condition, and the river was crossed with no damage to the outfit, the water coming only to the wagon box. North of this the trail becomes worse, being quite stony in places, while several short and rather soft muskegs were crossed, some of them requiring brushing.

Owing to the heavy rainfall of June and July, mud holes were numerous on the final third of the trip. We arrived at the third meridian in three and a half days from Prince Albert and a good observation spot was at once chosen. Much rainy weather was experienced here, but by July 27 sufficient observations had been taken and the return journey commenced. The recent rains had flooded Red Deer river to an unusual height, but it had abated somewhat on our arrival. It was necessary to swim the horses and raft the outfit across; this was accomplished without difficulty or damage to the outfit although the water was about nine feet deep. Rabbits, partridge and prairie-chickens appeared to be numerous in this district.

I next proceeded to the sixth meridian in Jasper park by way of Edmonton and the Grand Trunk Pacific railway. At that time fully-equipped passenger trains were running as far as Fitzhugh in the Yellowhead pass. I left the train at the Jasper park collieries, the post-office of this place being Pocahontas. This was not at first intended as a regular stop by the Grand Trunk Pacific railway, but owing to the development of the coal mines in the neighbourhood, the traffic seemed to warrant it. The company in charge is developing these mines to a considerable extent and is producing a fine quality of steam coal. The trail runs westward from the collieries about three and a half miles and there crosses Athabaska river by ferry, and proceeds westwards along the north side of the river. The sixth meridian crosses a large level flat, partially timbered, in township 48. I selected my observation station here owing to the level nature of the country and the apparently equal distance from the mountains to the north and south. The point of observation is about a mile from the ferry, and near the trail. The observation was completed by August 22 and the return trip to Edmonton made at once.

I proceeded next to Calgary to observe on the fifth meridian near triangulation station No. 1. This observation was completed on September 12.

On the receipt of a telegram requesting me to observe at the triangulation station on Sugarloaf mountain, I left for Enderby, from which place the station is reached most conveniently. The trail to Salmon Arm passes south of Sugarloaf mountain, but a branch trail east of the hill passes within half a mile of the summit, which is easily reached by pack horses from that side. Mr. M. P. Bridgland, D.L.S., loaned me his packer and ponies to place the Zenith telescope outfit on the hill. I observed for latitude on the summit in the immediate neighbourhood of the triangulation station. The crops near Enderby were very good last year, fruit, potatoes and market garden crops all being plentiful, and hay of good quality and quantity is grown on the level lands.

On completing the observation here, I returned to Toronto and after a redetermination of the dip circle constants was made, I left for Ottawa, where I arrived on October 25.

The following are the results of the observations on the initial meridian:—

The northeast corner of section 13, township 61, on the second meridian, as defined by its witness post, is 0.25 chains too far north.

The northeast corner of section 13, township 57, on the third meridian, is 0.31 chains too far south.

The northeast corner of section 13, township 48, on the sixth meridian, is 5.67 chains too far north.

Thirty observations for magnetic dip and total force and twenty-nine for magnetic declination were taken during the season.

APPENDIX No. 26.

ABSTRACT OF THE REPORT OF L. E. FONTAINE, D.L.S.

INSPECTION OF CONTRACT SURVEYS IN ALBERTA.

My field work for the season of 1911 was not finished until February 10, 1912, and from that date until the middle of March my time was occupied in preparing reports on the contracts inspected.

On March 21, I left Edmonton with one assistant and one chain-bearer to examine some corrections which had been made in contract No. 23 of 1909.

When returning from this inspection I passed close to certain townships in contract No. 20 of 1911, and although I knew that the work was not completed, I decided to traverse part of Saskatchewan river in township 39, range 9, west of the fifth meridian, as conditions were very favourable for doing the work.

I then returned to Edmonton on April 4 and after organizing my party proceeded with the inspection of contracts Nos. 25, 26 and 28 of 1911, in the vicinity of Edson, completing the work on July 12.

After reorganizing my transport outfit at Edmonton, I left on July 19 for the Peace River district to inspect contracts Nos. 1, 2, 3 and 4 of 1912 travelling via Athabaska Landing, Mirror Landing, Grouard, Peace River Crossing, Dunvegan and Grand Prairie. When this work was completed I returned to Edmonton on November 18, via Edson, and paid off my party.

On November 25, I left for township 42, range 28, west of the fourth meridian, to resurvey the north boundary of the township but owing to an accident to my transit I was unable to complete the work. I therefore closed operations and left for home, arriving there on December 12.

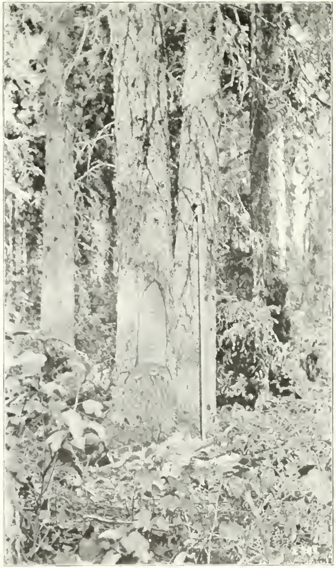


Photo by A. H. Hawkins, D.L.S.
Bench Mark on Twenty third base line west of the Fifth Meridian.

Photo by A. H. Hawkins, D.L.S.
Twenty-Third base line west of the Fifth Meridian Range 18.

APPENDIX No. 27.

ABSTRACT OF THE REPORT OF C. A. GRASSIE, D.L.S.

SUBDIVISION SURVEY IN JASPER PARK.

I have the honour to submit the following report of surveys performed in the Yellowhead pass district during the past season.

My work consisted of subdividing lands along the Canadian Northern railway now under construction, within the limits of Jasper park.

After a few days spent in organizing my party, I left Edmonton on June 10 via the Grand Trunk Pacific railway for Hinton, arriving there on the same day. We were delayed there two days waiting for the arrival of our supplies. On June 13 we proceeded by pack-train to township 49, range 27, west of the fifth meridian, camping on the right bank of Athabaska river near the mining village of Pocahontas.

From this camp we began subdividing in townships 49, ranges 27 and 28. The river traverses the lands that were to be subdivided. A considerable part of the lowland along the river was covered with water to such a depth that we were forced to abandon the work, leaving it to be completed later in the season when conditions would be better for surveying. We succeeded, however, in running two lines across the river.

The Jasper Park Collieries Company, Ltd., employ several hundred men in their coal mines in this district, and have been shipping coal for some time. The coal is bituminous. During the autumn and early winter of the past year they made extensive improvements to their plant, having built a large tipple and power-house. The Grand Trunk Pacific railway passes through township 49, range 27, following the right bank of the river.

On July 4 we moved camp to the west shore of Brulé lake, an expansion of Athabaska river. We transported the camp outfit and supplies across the river by boat, but had to send our horses around by way of Prairie creek on account of not being able to find a suitable place to swim them across the river.

In this district we subdivided those parts of townships 49 and 50, range 27, which are adjacent to Brulé lake. A good wagon road from Prairie creek follows the western shore of the lake to its head. The foot of Bullrush mountain is very close to the lake at the southern end, leaving only a narrow strip of valley between it and the lake shore, but this strip gradually widens towards the north.

The land is rolling and covered with small poplar and spruce. The soil consists of a sandy loam and clay mixed with sand. It would produce small fruits and vegetables, although light frosts occur in June. I chanced on a small garden in which all varieties of vegetables were grown with success. Wild strawberries were very plentiful.

Along the shore of the lake there is a strip of timber, chiefly spruce. Solomon and Moose creeks abound with trout for some distance up from their mouths.

The grade of the Canadian Northern railway, which follows closely the west shore of the lake, is nearly completed. Looking toward the east from the higher lands one gets an extended view of the lake and of the foot-hills, covered with forests of green spruce, while towards the west rises Bullrush mountain.

Brulé lake is being filled in with sediment brought down by the river, and consequently is very shallow. In autumn and winter when the water is low, the greater part of the bed of the lake is dry.

After completing the work in township 50, we continued our surveys in townships 49, ranges 27 and 28. Considerable difficulty was encountered in running the

subdivision lines across the Athabaska, as the river here is divided into several channels by islands which are covered with scrubby spruce and a thick undergrowth of brush, and contain swamps in their interior.

The land on the south side of the river is flat and low, being partially flooded during the time of high water, while that on the north side is rolling and hilly and covered with a scattered second growth of jackpine and spruce. A great part of these lands on the north side of the river and in the valley of Moose creek is leased for coal claims. The Jasper Park Collieries Company, Ltd., are developing their coal claims in township 49, range 27.

We also surveyed sections 24, 25 and 36 in township 49, range 1, west of the sixth meridian, and resurveyed the sixth meridian from the thirteenth base through township 49.

Bears and deer are plentiful in this district. The soil is clay on the high lands, while that of the low lands is clay and sand. Bordering the river, there is a narrow strip of timber consisting chiefly of spruce varying from four to eighteen inches in diameter.

On August 30, we began the subdivision of lands along the western shore of Jasper lake, and in townships 47 and 48, range 1, west of the sixth meridian. Jasper lake is also an expansion of Athabaska river, and, like Brulé lake, it is being filled in with sediment brought down by the swift waters of the river. During the time of low water, much of its bed is uncovered. Its banks on the west are high and steep, while on the east they are low. Immediately to the east, and separated from it by only a narrow strip of land, lies Talbot lake.

The country is rolling and hilly, and most of that part of township 48 which we surveyed is brulé, many fire-killed trees still standing. In some places windfall lies thickly on the ground. Rocky foot-hills rise from the shore at the head of Jasper lake, but farther south the valley widens again and the country is covered with small spruce and poplar. Part of section 5 township 47 is swampy and, in the western part, timber was seen up to three feet in diameter. Stony river flows through the northern part of township 48. It is a turbulent and swift-flowing river, whose waters flow through a deep and narrow channel until they near the sixth meridian where they spread out over a wide bed with low banks.

From this work we proceeded to Fitzhugh, a divisional point on the Grand Trunk Pacific railway, and situated on the left bank of the Athabaska. Here we surveyed the east and south boundaries of section 9, township 45, range 1, west of the sixth meridian. Miette river flows through this section. That part south of the Miette is brulé sparsely covered with small poplar, and that north of the river by jackpine. Along the banks there is spruce and fir, up to two feet in diameter. The Athabaska flows through the southeastern part of the section. The land here slopes sharply towards the river. The soil is a sandy loam with a gravel and stony subsoil.

Our next work was the survey of those sections in townships 45, ranges 2, 3 and 4, through which the Canadian Northern railway is being constructed. The land surveyed lies in the Miette valley, on the south side of the river. The valley is narrow, the mountains on the south rising almost immediately from the edge of the river. The greater part of these lands, therefore, is on a mountain slope and is exceedingly rough and rocky. In range 2 they are thickly wooded with small spruce and jackpine. In ranges 3 and 4 there is spruce and balsam timber varying from four to eighteen inches in diameter. The north side of the valley is mostly brulé, with scattered jackpine and spruce. A wagon road from Fitzhugh follows the river closely.

The summit of the Rocky mountains was traversed through sections 13 and 24, range 4, west of the sixth meridian. In sections 13 the summit is very much broken and was difficult to follow.

After having completed the survey of subdivision lines in this district we traversed Miette river from the east boundary of section 7, range 2, to its mouth, and

the Athabaska through townships 45 and 46, range 1, west of the sixth meridian; also of the Rocky and Stony rivers through subdivided land. Most of the traversing had to be done on the banks of the rivers, as very little ice had yet formed.

We completed the traverse of Stony river early in December, but were unable to ford it on account of its flooded condition, due to a blockade of ice. We were therefore unable to finish the surveys in township 49, range 27, west of the fifth meridian.

We accordingly ceased operations and took the train at Pocahontas for Edmonton. Arriving there on December 11, I disbanded my party, and having stored my outfit I left for Medicine Hat on December 17.

APPENDIX No. 28.

ABSTRACT OF THE REPORT OF A. H. HAWKINS, D.L.S

SURVEY OF THE TWENTY-THIRD BASE LINE WEST OF THE FIFTH MERIDIAN.

My work during the season of 1912 consisted of the survey of the twenty-third base line, from the fifth to the sixth meridian.

By arrangements made in 1911, hay was put up for use on this line, at Quitting lake in range 3 and also at Peerless lake, range 5, and caches of provisions were arranged for on Peerless lake, on Otter lake in range 13, and on the Peace river at the mouth of Whitemud river, in range 21. Arrangements were also made to have a sleigh road cut from Lubicon lake on the twenty-second base line, to Otter lake on the twenty-third.

The party left Edmonton, by wagons, on March 11, and were met at Athabaska landing by my packer who had been sent in some time previously in order to have certain horses from the pack-train put into harness, as it was found to be a difficult matter to secure freighters to go in the required distance, except at very advanced rates; however, as arranged, the sleighs were ready and the party left Athabaska Landing by way of Athabaska river, on March 16, passing Fish Camp, Calling lake, Rock Island and Pelican or Wabiskaw mountains en route.

The road up the southern slope of these hills is well located but, from the summit to the foot of the northern slope, the locator evidently had little or no regard for grades, steep pitches, or sharp turns, which are far too numerous, and, moreover, are not necessary. However, the party succeeded in overcoming these obstacles, and reached Wabiskaw on March 22. After making some necessary repairs, we continued our journey northward, following the winter road put in by the Hudson's Bay company and Messrs. Revillon Bros. to the Trout Lake trading post. This was the last outpost of a very limited civilization, that we were to visit for some time.

From this place our route followed the east shore of a small lake, locally called Trout lake, to where a stream flows into it at the northeast extremity, and thence up this stream and across a small lake locally known as Island lake. A trail was cut from the north shore of this lake to the east side of Quitting lake and camp was established near the north shore of the latter. By observing, it was ascertained that the camp was very near the latitude of the twenty-third base line.

Our sleighs were sent back from this place, and a trail started eastward to the starting point of the survey on the fifth meridian, and as the snow was still from one to two feet deep in the woods the task was a very laborious one. It was not until April 8 that the party were in a position to start the base line westward.

During the first few weeks the work was rather slow and disagreeable on account of the deep snow, and on April 11 a violent snowstorm prevented work for two days.

Peerless lake, or, as it is called locally, Trout lake, situated in range 5, was reached on May 4, which was not a moment too soon, as the ice was beginning to be very much honeycombed, especially along the shores. In order to reduce the danger to a minimum the line was produced across the lake on Sunday, and the camp moved to the west shore.

The cache previously arranged for was found to be about twenty chains to the south of the line, in an excellent position and in good condition.

Peerless lake is a very fine sheet of water, from three to six miles wide, and from twelve to fifteen long. A small creek, navigable for canoes, connects the southern

end of the lake with another small lake, on the southern shore of which is situated the Trout Lake trading post. There are no rivers of any size flowing into either of these lakes, and, judging from the appearance of the water and the depth of the larger lake, they are probably fed by large springs. The water was clear and good and not at all like the muskeg drainage, which, with the exception of the water in Peace river, was what we had all along this line. Both this lake and the one to the south are said to teem with fish; bull trout, lake trout, pike, whitefish and sucker are said to be abundant, and the fact that several families make this lake their headquarters would seem to confirm the report.

The country between this lake and the fifth meridian is largely burnt-over muskeg and low ridges, and the soil on the ridges is generally sandy. In a large measure this description applies to this section as far as range 18. Muskeg and windfall were the predominating features. The valley of Loon river in range 9 was, at the time of my visit, one vast muskeg and in many places a shaking bog, but along the west bank, not more than half a mile distant from the river, was found the first good horse feed of the season, on June 3.

The river varies in width from one to one and a half chains, and is from one to three and a half feet in depth, with a current of from two to three miles per hour. The water very markedly indicates its muskeg origin, and I was credibly informed that the muskegs increased in area and softness farther north, and all the country to the south draining to this river is more or less muskeg.

The party lost a week, getting around the muskegs on the west side of Loon river, as it was found necessary to follow an old trail south along the river to Loon lake, and thence along another trail to the west of the muskegs.

I was fortunate in being able to secure some assistance in packing through this country, as the flies at this time were extremely bad, and the help in packing gave our ponies a chance to hold their own.

The shores around Loon lake are largely muskeg and windfall, and are very marshy along the water's edge, but they support a very vigorous growth of marsh grass and redtop, from which many hundreds of tons of hay could be cut.

The cache on Otter lake was reached on July 6, and the supplies were found to be in fair condition, but in the immediate vicinity of the lake horse feed was very scarce. This cache was found to be about one mile north of the base line and in range 13, in place of range 15 as shown on the maps.

From Otter lake to range 18, the country was all muskeg and ridges covered with very heavy windfall. The extremely dry season was of very material help to the party in getting through this part of the country.

In range 18 the line approaches the valley of Little Cadotte river, where muskegs are not so numerous, and the soil appeared to improve. From range 18 to Peace river are many fine plateaus, although the valleys of creeks flowing into the Peace are, as a general rule, very rough and broken. There are, however, many patches of good grass, redtop and pea-vine, and a few clumps of large spruce and poplar. In many places to the south of the base line there is heavy windfall. The line followed the Cadotte valley to section 32, range 20, and was so very rough and broken by slides and windfall that the levels were taken along the creek bed, to save both labour and time.

The Peace valley, where it is crossed by the base line, is exceedingly rough and broken, with cut banks, windfall and brush, and there is no grass to speak of. The plateau on the east side of the Peace is a rather fine tract of country and, if accessible, many fine ranches for cattle and horses could be selected, especially in townships 88 and 89, ranges 19 and 20. These townships would be almost ideal locations, as there is sufficient good level land to raise all the hay required, and the broken country is generally very good grazing land, and affords good shelter in rough weather, while the two branches of the Cadotte provide an abundant and permanent supply of good water.

Peace river is from one-half to three-quarters of a mile wide at this point, with several islands along its course. Water was low at the time of my visit, and was falling at the rate of about one foot in three days. The banks on either side are generally gravelly and stony, with many patches of quicksand, and many very large gravel bars and sandbars projecting into the water. The banks at this time of the year averaged from fifteen to eighteen feet above the water.

No minerals of economic value were seen along the river, but some drift coal and many curious fossils, probably of the Carboniferous age, were noticed among the drift that littered the shores. The river has a current of three to four miles per hour and, at the time of my visit, would range in depth from ten to twenty-five feet. There are very few fish, and the water until it begins to freeze up, has a decidedly milky appearance, but is fresh and good to the taste.

Arrangements were made previously to have a boat awaiting our arrival, and our cache was placed at the mouth of Whitemud river. Everything was found to be in order on our arrival.

The transfer of the pack-train was our most serious difficulty, and to reduce to a minimum the chances of losing our ponies, it was decided to take them across one at a time, and after a strenuous day, they were all landed without accident.

The side of the valley to the west was covered with a fair growth of birch and poplar with a few large spruce up to eighteen inches in diameter. Within a quarter of a mile of the top we again ran into muskeg which, however, did not extend far, ending in range 21. The country along the base line in the west side of range 21, through range 22 and south of the line in ranges 23 and 24 is a very fine tract of land, rather open and dry, generally covered with good grass and having sufficient timber for fences, buildings and fuel. This tract extends south practically to Peace river. Range 25 is largely muskeg which extends to the foot of Clear hills, where the sixth meridian was reached, and the twelve miles north along the meridian were largely muskeg and windfall, the few open patches along the creeks being exceptions.

While camped in range 23, the party were forced to retire on account of forest fires, which had apparently been raging for some time, as the air had been filled with smoke for several weeks. On the evening of September 28 the explorer returned and reported that the country to the south was all on fire, and that the fire was within one and a half miles of the camp, and was coming in our direction. At day-break the following morning we pushed our way to the south over the burning and burnt lands to safety. O few of the horses were scorched a little and the whole party was thoroughly smoked, but otherwise we suffered no harm. Rain fell two days afterwards and the fires, although not entirely extinguished, were checked so that we were able to proceed with the line. Through the burnt country, work on the line and trail was reduced to a minimum, as in many cases windfall and brush were cleared off in a most thorough manner.

The twenty-third base line was completed to the sixth meridian on October 11, and we had the good fortune to meet Mr. J. R. Akins, D.L.S., who was surveying the base line from the west.

The sixth meridian was produced north twelve miles by October 26, but provisions were running low, and the horse feed was very scarce and poor, the summer frosts apparently having injured it before maturity, and as winter was apparently coming on, it was decided to close work for the season. Before leaving, a good cache was erected one-half mile west of the end of the line, and a sleigh road was cut to connect with the road from Bear lake to Peace River Crossing.

The party started for Edmonton on October 25. Small lakes and streams were covered with ice that would carry a man at this time, but ice was still running in the Peace on November 1 when we reached that place. It was therefore found necessary to arrange for wintering the pack-train on the west side of the river, and, accordingly, Mr. Sutter was engaged to take it to the valley of Whitemud river, as this locality had not been burnt over, and grass was both abundant and good.

In all, one hundred and sixty-two miles of line, twelve of which were on the sixth meridian, were surveyed between April 8 and October 23.

Observations for azimuth were taken along the line on all possible occasions, and some two hundred were secured throughout the season. During the months of June and July a hazy sky rendered observing most difficult, as even after sunset the Pole star was most difficult to find.

Throughout the season, rabbits, partridges, spruce hens, willow grouse and prairie-chickens were seen in large numbers. Bears were noticed all along the line, and moose were fairly numerous, and along the valleys of Peace and Cadotte rivers, red deer were noticed. Waterfowl were quite numerous on all the small lakes and streams.

The climate in this locality is very similar to that of the country farther south. The summer was very dry and hot, and flies were very bad indeed. Summer frosts were prevalent, doubtless owing to the large tracts of muskeg to be found everywhere along the line, but the country along the Peace, and more particularly along its west side, would be very good for mixed farming; horses and cattle, it is thought, would do especially well.

APPENDIX No. 29.

ABSTRACT FROM THE REPORT OF G. H. HERRIOT, D.L.S.

SURVEY OF PART OF THE PRINCIPAL MERIDIAN.

I left Ottawa on April 28, 1912, and proceeded to Edmonton, where I spent several days in conference with Mr. A. W. Ponton, D.L.S., from whom I received much valuable information with regard to the production of the principal meridian. I then returned to Winnipeg and proceeded to organize my party.

On June 4, with a party of sixteen men, I left Selkirk on the Northern Fish company's steamer *Wolverine,* and reached Warren's landing on the 6th. There we transferred to the Hudson's Bay company's boat *The Highlander,* and proceeded down Nelson river to Norway House. On June 8, after hiring two Indian guides, we left for the scene of our season's work. As our canoes were heavily loaded, and most of the men without experience in canoes, and as Little Playgreen lake was very rough, I was compelled to hire the Hudson's Bay company's launch to tow us across the lake. On the 10th we camped on the east side of Nelson river at a point from which we intended to go into the northeast corner of township 60, range 1, west of the principal meridian. The following morning we made up our packs, and, guided by the two Indians, we set off. That was a terrible day for the inexperienced men, but after travelling about seven or eight miles we finally reached the starting point for our season's work.

I had ordered my supplies as early as possible from the Hudson's Bay company at Winnipeg, giving instructions to ship them by the first trip of the steamer *Wolverine* to Norway House. These goods went up on the same boat as my party, so that no delay was caused by waiting for them. They were all moved by my own canoes from Norway House down to the camp on Nelson river. When leaving Winnipeg I left orders for a second shipment of nearly five tons of supplies to be sent to Cross Lake post. These were shipped to Warren's landing by the Northern Navigation company's steamer, there transferred to the Hudson's Bay Company' boat, and taken down across Big Playgreen lake to Whiskeyjack portage. They were there unloaded from the steamer to a white boat, rowed to shore. loaded on a wagon, and hauled across the portage, a distance of about six miles, where they were again unloaded and placed on a York boat and rowed to the Cross Lake post, a distance of about twelve miles. Here they were again unloaded and carried up to a store tent. From this tent my canoe men from time to time drew their supplies, and so long as the work was in the vicinity of Cross lake this was a simple matter, but when the canoes had to go around to Sipiwesk lake it was necessary to send practically all the canoe men with four loaded canoes around from the post.

On June 12 the production of the line was commenced, after first correcting the position of the northeast corner of township 60, and from this time on the work was continued with as little delay as possible. On June 19, Nelson river was reached and, within the next six miles of line, nine channels of the river were crossed. On August 2 the line reached Cross lake where, after a series of triangulations across various arms and bays of this lake, we finally reached the north shore on August 10. A wide strip of country was next crossed, with no waterways until. on September 3, Sipiwesk lake was reached. In this lake we also encountered innumerable bays, channels and islands, necessitating the measurement of many triangles. On the

24th, the north shore of this lake was reached, and the line was produced about five miles farther by the 30th.

On October 1 we broke camp and started back to Warren's landing, arriving there on the 10th, and sailing from there on the steamship *Wolverine* the following day. We arrived in Selkirk on the 13th, and the following day I paid the men off.

METHOD OF CARRYING ON THE WORK.

The work of producing the line and of taking the necessary observations was carried on by myself, while to the two assistants and the chinamen was left the work of chaining, check chaining, levelling and check levelling. The first assistant, with one of the chainers, did the chaining and check levelling, while the second assistant did the levelling and check chaining. The work of bringing supplies down the river from Norway House was left to the head packer. He, together with five men, also had charge of the work of moving camp, but in order to assist him as much as possible, on moving days every man packed his own bed and clothing, together with the sleeping tents, to the end of the cutting or possibly right through to the new location for camp. The packers would bring up part of the cook's outfit and pitch camp, then return for another load. In order to keep the supplies up with the work the packers would take a load or two ahead the day before we expected to move, then the day after moving they would probably have the remainder to bring up to camp, as well as a load to move on ahead. In this way six or seven men were able to keep sufficient supplies in camp. The rivers and creeks were utilized as much as possible, and the supplies moved along them in canoes to the nearest point to the work, and from there packed into the camp. Whenever a wide stretch of country was crossed without watercourses that could be followed, it was necessary to send the packers, who were all good canoemen, around with supplies to a point where we expected the meridian to strike the next waterway, and not infrequently the packers would be away for two or three days; in one case they were away for five days. During these periods if camp had to be moved, everyone had to make a second trip and so no cutting was done on the line.

NELSON RIVER.

The whole area covered by our season's work is drained by Nelson river, and the various creeks and streams that are tributary to it. This river carries the overflow waters from lake Winnipeg and the immense territory that pours its waters into that lake. Where all the water is confined to one channel it is nearly a quarter of a mile wide, but this seldom occurs as the river is noted for its intricate maze of channels. Its water divide from Great Playgreen lake, part taking the East and part taking the West channel. Each one of these channels has its different widenings forming lakes, or its branchings forming a net work of channels, but they finally converge to pour their combined waters into Cross lake, a very picturesque lake with innumerable bays and islands. The waters from this lake find their way northward through a continuation of Nelson river, and after a devious course at length empty into Sipiwesk lake, the most beautiful of all these northern lakes. Although the Indian name 'Sipiwesk' implies a lake with many hay marshes along its shore, these marshes do not in any way detract from the natural beauty of such a body of water. This lake is much like Cross lake with its many islands and deep bays and channels, except that the channels are much narrower, and therefore show a much more marked current. One interpreter informed me that Sipiwesk meant a lake of rivers or channels. This interpretation is very applicable.

As already stated, the Nelson is a river of many channels, carrying an immense volume of water, its total discharge being almost as great as that of the St. Lawrence.

Between the point at which the meridian first crosses the river and Sipiwesk lake there is a total fall of 104 feet. Part of this great fall is distributed along the various reaches of the river. The remainder is accounted for by the many small rapids and several larger falls. In travelling from Norway House, Sea River fall is first met, with a clear fall of about 5 feet, then Sugar fall is reached where the fall is nearly 6 feet. Three other smaller rapids are met between there and Cross lake. Between Cross and Sipiwesk lakes the falls in the order in which they occur, and their heights are as follows:—

Ebb and Flow rapids..	11 feet.
Whitemud fall..	20 feet in fall and 10 feet in swift water below.
Bladder rapids..	10.6 feet.
Over-the-hill rapids..	9.5 feet.
Redrock rapids..	10.5 feet.
Chain-of-rocks rapids..	1.2 feet.

When one takes into consideration the enormous volume of water flowing over these rapids and falls it is not hard to realize the possibilities of this river for power production but, on the other hand, the number of these rapids and the falls, together with the fact that the fall between Norway House and Hudson Bay is approximately seven hundred feet, leads one to conclude that navigation of the river is not feasible for boats of large capacity.

Since the early years of the fur-traders, Nelson river has been used as a channel of entry to the interior of the country, and for years York boats have been taken up and down the river. Some of the rapids are run, while others must be passed by portaging. To the Indians in theYork boat such rapids as the Sea fall and Sugar fall are points of welcome excitement when going down stream. They row wildly to the edge of the fall and then lie back as their frail craft plunges into the troubled waters below. It is, however, with a very different feeling that they near it when rowing up stream, for they know that in this case it means the arduous task of portaging.

CHARACTER OF THE COUNTRY.

The country through which the meridian passes is sufficiently uniform for a few general statements describing its character. The surface is usually nearly level or undulating, being made up of a regular succession of swamps, muskegs, and low rocky ridges. The swamps are largely spruce and tamarack, with water standing from three to twelve inches deep, and covered with a stunted growth of timber. We also encountered frequent moss swamps where little water is found, and where the surface is covered with a thick layer of moss and with spruce and tamarack timber. The rocky ridges are mostly of granite formation and run in a northeasterly and southwesterly direction. They rise gradually to a height of ten or fifteen feet above the level of the surrounding swamps.

The northeast corner of township 60, range 1, west of the principal meridian, lies on the north slope of one of the largest jackpine ridges encountered in that country. The soil is a light gravelly sand, supporting nothing but a growth of jackpine, averaging from three to seven inches in diameter. As one works northward a large tamarack swamp is met. The trees here are very much stunted and of no practical use. to the east of the line the generally level surface of the country is broken by many ridges of outcropping rock, which in some cases rise thirty to fifty feet above the surrounding level. On the west, however, the swamp stretches away off toward the river. As one nears the northeast corner of township 61, the land becomes more undulating, falling gently towards Nelson river. It is broken by frequent outcrops of rock. On these rocky outcrops small jackpine grow wherever any soil is found; this soil is generally moss-covered black muck. Near the northern limit of the township the first crossing of the East channel of Nelson river is made.

Township 62 is very much broken by channels of Nelson river, as the river there has many large islands, most of them being covered with dense wood. Poplar and spruce form a fringe about the edge of the islands, while the interior is not so heavily timbered. Frequently, muskeg is encountered even on these islands. The soil, however, is much more suitable for agriculture, being in many places clay covered with a vegetable mould. In section 36 of this township the Nelson is crossed for the last time as it flows westerly.

Farther north in township 63 the swamps seem to become narrower and the recurrence of swamps and jackpine ridges become more frequent. The rocky out-croppings almost entirely disappear, although the rock comes to within a few inches of the surface on the summit of each jackpine ridge. The surface soils vary from a deep black muck in the swamps to a yellow clay on the ridges. This clay area would seem to indicate that this belt is really an extension of the great clay belt of northern Ontario. At the northeast corner of the township the line crosses a shallow, irregular lake about three miles long and two miles wide. Its waters overflow through a shallow meandering creek about a chain and a half wide, which, after a winding course of about two miles, finds its way into a branch of the Nelson not far from where that river expands into Pipestone lake. The latter is a rock-bordered lake, about five or six miles long and of nearly the same breadth.

The surface of township 64 is much more irregular, the southern portion being broken by high rocky ridges and intervening valleys. The northern portion, while less rolling, is still broken by the recurrence of rocky out-croppings and swamps. The soil is clay on the slopes of the ridges and black muck, covered by moss, in the swamps. Two small lakes occur close to the line and a third is crossed in section 36.

Throughout township 65 the surface of the country becomes more undulating and the swamps do not seem to be of so great extent. Even their character seems to change, and the tamarack swamps with much standing water seem to give place to the drier moss swamps covered with spruce, and broken more frequently by jackpine ridges. The soil, too, is of a better quality, clay loam being found in many parts. In section 36, Cross lake is reached. This lake is a long irregular body of fresh water surrounded by a rocky shore line. It is about six miles wide and probably fifty miles long, and is dotted with innumerable islands, many of which are very large. They are usually rock bordered and covered with a dense growth of jackpine and spruce, some trees reaching a diameter of sixteen inches. The lake abounds in whitefish, and is essentially an Indian paradise, with lots of wood and plenty of fish.

About fourteen miles southwest of the northeast corner of the township, and located on the shore of Cross lake, is the Hudson's Bay Co's trading post known as Cross Lake post. On the east side of the channel the Hudson's Bay Co., have erected three log buildings. One of these serves as a storehouse, the second as a store, and the third as a residence. In addition, two other traders have established trading posts at this point. North of the Hudson's Bay Co's store, Mr. Hire has established a post, and south of it along the lake, Mr. Mercer trades and barters for the Indians' furs. The best of relations exist between these rival trading houses. The welfare of the post is zealously cared for by Methodist and Roman Catholic missions, each one having a school in connection with it. On the opposite side of the channel lies a large island which either has been or is to be set aside as an Indian reserve, and here about four or five hundred Indians live during the summer, during which period the men are mostly employed on the Hudson's Bay Co's York boats, while the women spend their days in catching what few whitefish are running, for their own food as well as that of for their sleigh dogs. About the middle of September in each year these families leave for their various hunting grounds, and spend the winter hunting and trapping; and a rich harvest some of them make, for fur-bearing animals are plentiful and up till the present they have been practically unprotected.

The whole of township 66 lies in Cross lake and what land area exists is formed of islands covered with abundant growth of spruce and jackpine.

The meridian strikes the north shore of the lake in section 1 of township 67. This township is mostly low lying and very wet. The soil is largely black muck. Across the northern part of the township, where higher land is encountered and the country has not been so wet, bush fires have swept, so that this area is covered with the standing fire-killed trees.

As we worked northward into township 68 the burned area gave place here and there to tamarack swamps where it was too wet for the fire to run. The soil, too, seems to improve, and more clay is found.

Township 69 is more broken by small lakes than the one previously described. In section 18, east of the meridian, lies White Rabbit lake, a small lake with an outlet to the north leading to Sipiwesk lake. The country is covered largely with fire-killed trees, except where tamarack swamps intervene. The soil varies from a deep black muck to a heavy clay. In the northern part of the township Sipiwesk lake is first encountered. Sipiwesk is like Cross lake in that it is broken by innumerable islands, channels and bays. It is about twelve and a half miles from shore to shore along the meridian, and roughly thirty miles long. Many of its islands are covered with dense spruce, some trees reaching sixteen to eighteen inches in diameter. In some of the narrower channels of the lake the current is quite perceptible. Along a few of the islands large hay marshes occur. Whitefish and sturgeon are plentiful.

Townships 70 and 71 are broken by the many channels of Sipiwesk lake. The islands are largely covered with dense spruce. The soil on them is a deep clay except in the swamps, where black muck appears. In section 36, township 71, the north shore of Sipiwesk lake is reached.

The surface of township 72 is generally undulating, being covered mostly with fire-killed spruce and, in the hollows, tamarack swamps occur.

Throughout the whole of this area which the meridian traverses, fur-bearing animals are very numerous. Beaver, mink, muskrat, marten, red, black and cross foxes, lynx, wolves and otter are trapped in great numbers by the Indians. Moose are very plentiful, and provide the major part of the Indians' winter diet. Small birds are not numerous, but partridges are very plentiful, and wild ducks and geese frequent these waters in summer. Whitefish abound in the waters of all the larger lakes, such as Sipiwesk, Cross, Playgreen and Butterfly lakes, and also in Nelson river. Sturgeon were for years caught in large numbers in Sipiwesk lake, and I believe they are still to be found there in great numbers, although the sturgeon fisheries which were in operation on that lake a few years ago, have since been abandoned.

In conclusion, a brief summary of the various rapids to be passed between Norway House and Sipiwesk lake, with the approximate length of portage required to pass each, might be appended:—

Name.	How passed.	Description.
Sea River fall	Portage	About 150 feet long over a rocky island or by a shore route 15 chains long.
Sugar fall	Portage	On west side about 300 feet long over a rocky shore line.
Three small rapids	Portaging or tracking	Over short islands.
Ebb and Flow rapids	Portage	About one-quarter of a mile long.
Whitemud fall	Portage	Nearly half a mile long.
Bladder rapids	Portage	About one-quarter of a mile long.
Over-the-hill rapids	Portage	Only about 300 feet long, but over a hill 30 feet high.
Redrock rapids	Portage	Either: (1) By two short portages and then hauling the canoe over a high rocky hill, 30 feet or 40 feet high, or else letting it down by a line after lightening it; (2) portage about three-quarters of a mile long, with a hill 40 feet high at the north.
Chain-of-rocks rapids	Portaging or tracking	A short portage.

From the foregoing list of portages it is quite apparent that the work of transporting supplies in summer from Cross Lake post is quite a difficult one.

The winter transportation is even more serious still, for during the winter months dogs are the only means of transport or travel, and unless one has a base of supply fairly close at hand, this is a very expensive means. Moreover, dogs are hard to obtain and very expensive to buy, the price ranging from \$25 to \$30 each.

APPENDIX No. 30.

ABSTRACT OF THE REPORT OF A. LIGHTHALL, D.L.S.

SURVEYS IN THE NEW WESTMINSTER DISTRICT OF THE RAILWAY BELT, BRITISH COLUMBIA.

I received your instructions dated May 1, 1912, at Vancouver, and, in accordance therewith, I immediately organized my party and proceeded to Woodhaven, where my first survey work was located. The place is about eight miles from Vancouver, situated on the north arm of Burrard inlet and easily reached by steamers which make daily trips up the North arm. It is being laid out as a townsite, and is intended as a summer resort. The land is comparatively level and is covered with heavy bush, though most of the valuable timber has already been removed. Numerous skid roads have been built during the logging operations and, being still in a state of good repair, will probably be used as streets for some time. Part of this townsite lying close to the shore has already been disposed to private parties, and about a dozen houses have been built and are occupied during the summer months by their owners.

I next moved my party to Hope by railway and thence by pack train up Silver river to survey timber berth No. 554. There is a very good pack trail up this river, but pack horses are a little difficult to obtain just when they are needed, making transportation uncertain and expensive. The river is fairly large, being about one hundred feet wide and two or three feet deep near its mouth. The current, however, is very swift and the river is entirely unnavigable. It provides good fishing as it contains numerous fine, large trout. The river flows through a valley which varies from one-quarter to one mile in width. The bottom of the valley is very heavily timbered with cedar, fir and hemlock, some of the cedar reaching a diameter of thirteen feet. The hills on either side are very steep, and the timber thins out rapidly as one ascends. These hills rise to a height of five to six thousand feet, and some of them are covered with snow the whole year. No fires have ever run through this valley, and the land appears to be fairly fertile and will, no doubt, make excellent agricultural land when the timber has been cleared off. The Provincial Government is now building a fine automobile road up the valley, which will eventually connect Hope with Princeton, and afford future settlers an excellent means of communication with the outside world. At present the only inhabitants of this valley are a few trappers who catch bears, muskrats and marten.

I completed the survey of four blocks of this timber berth and also traversed the right bank of the river across section 5, township 5, range 26, west of the sixth meridian, and thence moved back to the north arm of Burrard inlet, to the survey of timber berth No. 555, which is situated in township 6, range 7, west of the seventh meridian. Several timber berths had already been laid out in this locality, but on retracing some of the lines I found that the old surveys were very much in error, and consequently I had to lay out timber berth No. 555 considerably larger than my instructions called for. This group of timber berths is laid out along the valley of Grand creek a stream about thirty feet wide and one foot deep at its mouth. In the last half mile of its course it descends about eight hundred feet and water-power has been developed on it to run a quarrying plant on the shores of the inlet. Above the falls is a basin of considerable extent where logging operations are now being carried on in timber berth No. 270. The land here will never be of much use for agricultural purposes after the timber has been taken off, as it is very rough. Around this basin the hills rise steeply to a height of about four thousand feet, the timber growing up to about three thousand feet, and the tops of the hills being quite bare.

After finishing timber berth No. 555, I moved to Pitt lake to the survey of timber berth No. 557. This lies on the west shore and about two miles from the head of the lake and, like most of the country around Pitt lake, is very rough and mountainous. The hillsides are covered with a fair growth of timber, but I should judge that the logging would be a rather difficult operation on account of the steepness of the hills. DeBeck creek enters the lake just to the north of this berth. This stream is about fifty feet wide and two feet deep, and as it has a good fall considerable water-power could be developed. Game is plentiful in all these mountains, but is very hard to get on account of the dense undergrowth. The creeks contain a considerable quantity of fine trout.

From Pitt lake I went to Sumas prairie in township 19, east of the coast meridian. The survey here consisted of the traverse of Anderson creek and Sumas river across lot 224, group 2. The country is perfectly flat and is covered with grass. It makes excellent grazing land but is subject to overflow from Sumas lake when the water is high, and is not used for agriculture to any great extent. It is well settled, the farmers going in for cattle raising on a limited scale. When it is dyked it will no doubt develop into a fine agricultural district.

From Sumas prairie I went by boat down Sumas and Fraser rivers to Langley townsite. This was orginally intended for the capital of the province and contained a court-house, jail, and several other public buildings, but when the capital was moved to New Westminster, the town was abandoned, and very few traces of the old buildings are left. The land is mostly wooded and is comparatively flat, and the lower portions are subject to overflow from the Fraser, but can be reclaimed by dyking, and made into good agricultural land. There is a peat marsh, however, in the northwest corner of the townsite covering about one hundred and fifty acres which will never be any use for agricultural purposes, the moss and peat going down to a great depth. Five of the original settlers are still on the land and the townsite was divided into six lots of about one hundred and forty acres each, one lot going to each settler; the sixth, being laid out in the peat marsh, was not claimed by anyone. The shore along the northeast corner of the townsite is being rapidly cut away by the river; in some places it has encroached over two hundred feet on the land in the last twenty years. The settlers are engaged in farming in a small way, and also depend for their living on catching salmon in the river. Grouse and pheasants are plentiful in these parts.

From Langley townsite I went to Ruby creek by railway. There I laid out fractional sections 30 and 31, in township 4, range 27, west of the sixth meridian, on the north bank of Fraser river. The land is well covered with timber, and parts of it, being fairly level, are well adapted for agricultural purposes. The best land, however, is taken up by Indian reserves, and as the Indians pay more attention to fishing than to agriculture, not much progress has been made on it. The climate appears to be a little drier and colder than it is nearer the coast, and high winds prevail, due no doubt to the narrowing of the Fraser valley.

From Ruby creek I returned to Hope, and from there went up Silver river where I laid out the remaining two blocks of timber berth No. 554. I reached there on November 18 and found that the season was becoming rather advanced for mountain work, the pack trail being considerably more difficult to travel over than on the previous trip. We were fortunate, however, in having a couple of weeks of fine weather and had just finished the survey of the two blocks when a heavy snowstorm came on which put a stop to further survey work in this district. I returned to Hope and thence went by rail to Agassiz; from there I went by wagon to section 16, township 4, range 28, west of the sixth meridian. There I laid out the southwest quarter of the section for a settler named McLean who had been living on it for six or seven years. About fifty acres of this quarter is good flat land, the rest of it lying on a hillside is of no use for agricultural purposes. A considerable amount of flat land adjoins this quarter on the east and is occupied by a very prosperous looking farming community.

On completing this survey, I paid off most of my party and took the remainder down to Westminster Junction and from there up Pitt river to township 41, east of the coast meridian. There I corrected the positions of the posts on the east boundary of section 12, and also on the east boundaries of the northwest and southwest quarters of section 12. This work was done in a heavy rainstorm, which made the trip very unpleasant.

That completed all the surveys for which I had instructions, with the exception of a small survey near Stave lake, and as I considered that this survey could be done more advantageously at the beginning of the next season, I returned to Vancouver, paid off the remainder of my party and closed operations for the season.

Photo by E. Deville, D.T.S.
Looking up Athabaska River, Jasper Park

Photo by H. Matheson, D.L.S
Fiddle Creek below the Canyon, looking towards Athabaska River.

APPENDIX No. 31.

REPORT OF G. J. LONERGAN, D.L.S.

INSPECTION OF CONTRACT SURVEYS IN ALBERTA AND WESTERN SASKATCHEWAN.

BUCKINGHAM, QUE., February 15, 1913.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa, Canada.

SIR,—I have the honour to submit the following report on my survey operations of last season:—

My first work was a correction survey in townships 63 and 64, ranges 3 to 10, west of the fourth meridian. The best way to reach these townships is to follow the Cold Lake trail from St. Paul de Metis as far as the west side of Chicken hill, and from that place there is a faint trail leading north, known as the Mosquito Lake trail; it crosses Beaver river in section 5, township 63, range 8, west of the fourth meridian, and continues straight north about six miles, where it crosses the survey contractor's trail along the north boundary of township 63. The latter trail goes east to Cold lake and west to lac LaBiche trail. These townships are heavily timbered, except townships 63, ranges 5 and 6; on these there are many fairly open sections. The soil is generally a clay loam, and in a few places there are large hay marshes. There is no doubt that ranching would be the most profitable occupation for a new settler. The St. Paul settlement does not extend farther north than Beaver river. There are prospects that a railway will soon cross this district, as the Canadian Northern Railway company has already started a road north from Edmonton; last November they had 69 miles graded.

Having completed the work I returned to Edmonton and, after purchasing more supplies, I drove to Athabaska Landing, then west about forty miles to inspect two contracts. There is a good trail from Athabaska Landing as far as Baptiste lake, and from there the only trail is the one made by the contractor. Township 64, range 26 has been burnt over almost clear of everything. The land is dry and the soil a clay loam, but in township 63 of the same range it is chiefly tamarack swamp. Townships 65 and 66 ranges 26 and 27 are dry rolling country, having a clay loam soil, covered with poplar and scattered spruce from six to eight inches in diameter. When the timber is cleared from these townships they will make good farm land. I might add that the railway leading to the Peace river country, and which is now partly constructed, will pass through these townships.

Having completed the inspection of these two contracts I went to Red Deer to subdivide a township that was previously covered by Cygnet lake. On my arrival I found that the contractor who was draining the lake had met with difficulties, and had not completed his work. I was accordingly obliged to postpone the survey for the time and started to repost township 53, range 25, west of the third meridian. Saskatchewan river cuts through the southwest part of this township, and for about a mile on either side of it the land is so cut up by ravines, and is so rolling that it is fit for nothing but pasture land. The remainder of the township is fairly level, having a sandy loam surface and a clay subsoil. A number of settlers have started farming and they appear satisfied with their choice of location.

Leaving there about the end of August, I started for Heart lake, which is northeast of lac LaBiche, to inspect Mr. Davies' contract. At St. Paul I was advsed to

go by way of lake St. Vincent, thence to the forks of the big and small Beaver rivers and follow up the shore of the little Beaver until I would strike the lac La Biche trail. In my opinion it would be best to go by some other route, even if the distance was greater. From the east end of lac La Biche there is a trail that leads to Heart Lake; it goes up and down all the high hills, and a good team can haul only about 1,000 pounds on it.

This contract, comprising townships 69 and 70, ranges 10, 11 and 12, west of the fourth meridian, is high rolling country, covered with poplar and scattered spruce, six to eight inches in diameter. There are a few large tamarack swamps to be found, and many large lakes, most of which are well stocked with fish. A few families of Indians live around Heart lake and exist entirely upon fishing and hunting, no attempt having been made at cultivation, although the soil appears to be as good as elsewhere. Leaving here on September 10, I went to inspect Mr. Green's contract, comprising townships 41, 42, 43 and 44, range 7, west of the fifth meridian. I went west from Red Deer on the Rocky Mountain House trail as far as Leslieville, and from there northwest along the south bank of Lobstick creek. This trail ends in section 35, township 40, range 6. It being impossible to continue with wagons, I packed a tent, a few blankets and provisions and started cutting a pack trail, doing inspection and moving at the same time. The country is rolling and thickly timbered with large spruce and poplar, and the soil is a clay loam. The best of the spruce is already taken up in the form of timber berths, and there is a saw-mill in operation on Lobstick creek, which will do custom sawing for the settlers at reasonable rates. I might remark that it is impossible to reach these townships during summer by going west from Wetaskiwin to Buck lake. On my way in I was agreeably surprised to find such a large tract of fertile land. It was thickly settled from Red Deer west, and the farmers had a prosperous appearance. I counted seventeen threshing outfits in operation. Leaving Mr. Green's contract I went to inspect Mr. Ord's, in townships 61, 62, 63, 64 and 65, range 18, west of the fourth meridian. From Pakan to Smoky Lake post-office there is a good road, and from there a surveyor's road going north in range 17 to Buck lake and then to lac La Biche. In township 61, range 17, there is a branch trail leading into range 18, and thence northerly. Townships 61, 62 and 63, range 18. were overrun by fire, a few years ago and are now either entirely cleared or covered by windfall. The soil is a clay loam, and the surface very rolling. There are a few Galician families settled on the south part of township 61, but the most of the country is still open for entry. The northern two townships are heavily timbered with poplar and scattered spruce, six to eight inches in diameter. The large number of small lakes and swamps has protected them from fire.

It might be of interest to prospective settlers to know that from Pakan, north, east and west, the country is settled almost entirely by Galicians, and judging from the appearance of the buildings and stock they are in a prosperous condition. They still retain the language and customs of the old country.

My next work was in townships 63 and 64, ranges 3, 4, 5 and 6, west of the fifth meridian, but as all roads start from Edmonton and radiate in different directions it was necessary to once more return to the capital; from there I followed the Lesser Slave lake trail to reach my destination. It was fortunate that the ground was now frozen over, for from Belvedere to Holmes crossing, during wet weather, is to be found one of the worst trails in Alberta. There is some very good land in these townships, but generally for a few miles back from the river it is chiefly sand hills, covered with jackpine, and between the hills are to be found tamarack swamps. I met no settlers located in the townships in this contract, but came in contact with an engineering party locating a railroad to strike the east end of Lesser Slave lake at Sawridge. In conversation with the engineer in charge, who had been over the country as far as the lake, he said the railway would pass through a lot of very good farm land. In November the location was passing through range 5. Throughout the contract there

were found along the creeks many large open places covered with a luxuriant growth of grass. If settlement would not rush in too quickly it would certainly prove to be a good ranch country. Holmes crossing is quite a busy place, it being the headquarters for settlement extending northwest along Freemen river from the Assiniboine flats.

After completing this work I returned to Edmonton and disposed of my transport outfit and reduced the number of my party. I then went by train to Medicine Lodge, where I engaged a team to move camp and supplies. I drove about eighteen miles north of the railroad on the trail that had been recently opened out to go to Grande Prairie and the Peace River district. As far as I could see, the country is a succession of rolling sand hills covered with small jackpine or scrub spruce, and up to the present no attempt has been made at farming. I completed the inspection of this work and then returned to Edmonton, where I paid off the remainder of my party and took the train for the East.

I have the honour to be, Sir,

Your obedient servant,

G. J. LONERGAN, D.L.S.

APPENDIX No. 32.

REPORT OF E. S. MARTINDALE, D.L.S.

SURVEYS IN SOUTHERN ALBERTA.

AYLMER, ONT., February 12, 1913.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa, Canada.

SIR,—I have the honour to submit the following report on my surveys in Southern Alberta during the past season.

I left Aylmer on May 9 and proceeded to Calgary, where I engaged my men and organized the party. The transport outfit which had been wintered at High River was shipped to Medicine Hat, from which place we were to commence retracement surveys. Being somewhat delayed at Medicine Hat by heavy rains and the non-arrival of freight from Calgary, we did not reach township 6, range 2, west of the fourth meridian, the scene of our first work, until May 30. Townships 6, ranges 1 and 2, were then retraced, and having received your instructions for the surveys in the mountains, the retracement work was brought to a close. The outfit was taken to Irvine, a small village on the main line of the Canadian Pacific railway about twenty miles east of Medicine Hat and from there shipped to High River.

Townships 6, ranges 1 and 2, are reached by good wagon trails through partially settled country. This country is not very productive and varies from gently-rolling to broken and hilly prairie. The soil is mostly a sandy loam from four to ten inches in depth underlaid by a hard gravelly subsoil, in some places the surface is stony. These townships are but a short distance south of the bench of the Cypress hills, and owing to the high altitude, summer frosts are a frequent occurrence; hence, this locality is unsuitable for agriculture. Almost the whole of these townships is given over to ranching, horses being raised principally. A few homesteads have been taken up in range 2 but, after one or two unsuccessful attempts to raise a crop, several of these have been abandoned. So far there is practically no settlement in range 1.

Owing to the continuous heavy rains during the first part of July we were unable to leave High River for the mountains until July 9 and even then the roads were almost impassable, the mud being axle deep. The fifth base line was produced across range 5 and two miles of range 6 by the end of July. The whole month was very wet, and the work was greatly retarded on this account.

Subdivision surveys were then carried on in townships 17 and 18, range 6, west of the fifth meridian, and Highwood river was traversed across township 17, range 6, These townships lie between the Highwood range and the main range of the Rockies in very hilly broken country. However, it is easy of access by a good wagon road from High River, which has been built and is being maintained through the mountains by the Lineham Lumber company which operates the timber berths up Highwood river.

On the base line across range 5 the timber is scrubby jackpine, spruce and poplar, and is of very little value; the remainder of the Highwood valley has been well timbered with spruce and jackpine up to twenty inches in diameter, but the valley was swept by fire in 1910 and the timber is now fit for fuel only. Coal of good quality is found in these townships, and several large claims have been taken up.

Highwood river is a swift-flowing mountain stream, from which it would be rather difficult to develop power. Mann creek, or Cataract creek, flowing into the Highwood from the south in section 34, township 16, range 5, is another swift stream with numerous small rapids and waterfalls near the river. There appears to be a fall of over one hundred feet in less than half a mile near the mouth, and power could be developed there at reasonable cost.

Game is not plentiful, although a couple of deer and some mountain sheep were seen during the summer. Partridges were not numerous.

In September the outfit was moved up Storm creek over Storm creek pass into Kananaskis valley in township 20, range 9, west of the fifth meridian. The east boundary of range 9 was run nearly to the fifth correction line, and the subdivision work in township 19, range 8, was completed.

This country is most easily reached by pack trail from Morley on the main line of the Canadian Pacific railway. Kananaskis river has its source in the Kananaskis lakes, and flows in a narrow valley between two mountain ranges into Bow river, west of Morley. The river averages from one to one and a half chains in width and has a depth of from two to ten feet. There is a waterfall about twenty feet in height two miles north of the lakes, where considerable power might be easily developed. Pocaterra creek, commencing near Storm creek pass, empties into the river about twenty chains below the falls. The Kananaskis lakes in township 19, range 9, are two very beautiful bodies of water, the northern one being about three miles in length and from one-half to three-quarters of a mile in width and the other having a little larger area, but being more circular in shape. The valley of the Kananaskis was originally well wooded but having been burned over many years ago it is now mostly covered with a thick mat of windfall and small jackpine. Coal is also found in this valley, large outcrops being visible on the mountain side to the north of Pocaterra creek. Game is very scarce in this district.

On account of the severity of the weather in October, and also owing to the fact that our supplies were getting low, we were forced to leave some of the mounding on this work incompleted. We moved back again to the Highwood valley on the 21st of the month. Heavy snowstorms were then a daily occurrence in the Kananaskis valley and there was already a depth of over two feet of snow on the passes.

The subdivision in township 18, range 7, and townships 17, ranges 5 and 6, was completed by November 18, when it was decided to close operations for the season. Accordingly, the outfit was taken to High River and the party was there disbanded. Arrangements were made for wintering the transport at High River.

Accompanied by my assistant and one chainman I then proceeded to Elkwater lake in township 8, range 3, west of the fourth meridian, to survey the townsite for which you had given me instructions.

This townsite, which is situated in the Cypress Hills forest reserve is easily reached from Medicine Hat by a well travelled wagon road; it is located at the south-east corner of the lake at the foot of the northerly slope of the Cypress hills. A contour survey had been made earlier in the season by Mr. F. V. Seibert, D.L.S., and a proposed plan, to fit the configuration of the ground, prepared in your office, from his notes. It was found that this plan was quite suitable, and it was followed, with very few changes, in making the survey. This survey being completed, we returned to Medicine Hat on January 21, 1913.

I have the honour to be, Sir,

Your obedient servant,

E. S. MARTINDALE, D.L.S.

APPENDIX No. 33.

ABSTRACT OF THE REPORT OF H. MATHESON, D.L.S.

TOPOGRAPHICAL SURVEYS IN THE FIDDLE CREEK DISTRICT.

On May 20, I arrived in Edmonton and began to outfit for my season's work. On the 27th I left Edmonton by the Grand Trunk Pacific railway for Hinton, that being the farthest point west to which the railway would haul freight or passengers at the time. I left my packer and one assistant in Edmonton to see about loading my horses and supplies on the freight train which left Edmonton the following day. My party consisted of two assistants, a cook, a packer and three labourers.

On the 28th, I hired a team in Hinton to move the part of my outfit which had already arrived to Jasper park, and I established my first camp on the east bank of Fiddle creek, about a mile south of the railroad. The remainder of my outfit and pack horses arrived three days later.

On May 29, I started topographical work south of Fiddle creek canyon. The object of this work was to locate a road up Fiddle creek from Miette Springs station on the Grand Trunk Pacific railway to Miette hot springs, a distance of about eleven miles. I did the topographical work by the transit stadia method, the same as used by Mr. G. H. Herriot in this vicinity in 1911. Traverses were run in the area covered, and from the stations of these traverses stadia readings were taken on all prominent changes in slope. The stadia readings were reduced in the field by means of a slide rule, and a sketch was made on the spot on a scale of 400 feet to an inch, and with ten feet contour intervals. These sketches were afterwards used in making the road location. A line of levels was also run from a bench-mark on the Grand Trunk Pacific railway near Fiddle creek bridge to a point above Fiddle creek canyon.

From my first camp I completed the work around Fiddle creek canyon and north of it. Then I moved my outfit to the mouth of Morris creek, a tributary of Fiddle creek above the canyon.

The work around Fiddle creek canyon was very difficult, because many parts were inaccessible. In these places points were determined by intersections, that is, bearings were taken to the points from two or more stations. Vertical angles were also read to the points and the elevations determined.

From my camp at the mouth of Morris creek, I completed the topographical work, connecting with the work done by Mr. Herriot in 1911. I then proceeded to make a road location. For convenience I started at a point south of Fiddle creek canyon, and worked south towards Sulphur creek. The location follows the mountain side east of Fiddle creek from the canyon to the mouth of Sulphur creek, where it crosses Fiddle creek and follows the east bank of Sulphur creek to the springs. After locating the road to the crossing of Fiddle creek, I moved my camp to the junction of the two main forks of Sulphur creek, about one mile and a half north of the springs, and then, from a point about a quarter of a mile below the springs, I located the road north to the crossing of Fiddle creek and south to the springs.

After completing the road location from Fiddle creek canyon to the hot springs, I moved my camp to the spot where I had my first camp. Then I started at a point east of Fiddle creek canyon and located the road northerly to the Grand Trunk Pacific hotel site. I did not locate the portion between the hotel site and the railway, as this portion is fairly level and offers no difficulties. Just south of Fiddle creek canyon the location passes around a gully with almost perpendicular rock sides.

Here the road for about half a mile would have to be blasted out of a rock fall. I did not locate this part on the ground as it was inaccessible .

I located the road as an ordinary traverse, but placed stakes every 100 feet, also at prominent changes in slope, and on these marked the chainage from the starting point. I took levels along the traverse to find the elevations of all the points marked by stakes. I also took slope readings with a clinometer across the line of traverse at the different stakes, and took notes of the nature of soil or rock to be excavated. The greater part of the road location is along fairly steep hillsides, where numerous gullies of various size and other obstructions had to be crossed. From my topographical work I knew the points where these could be crossed most easily and the positions and elevations of these points. In making the location the level work followed close to the transit work, so that the elevation of each station occupied was known very closely. In this way I could arrange my grades to cross gullies and other obstructions at the proper elevation. The maximum grade allowed was eight per cent.

A road could be made to the hot springs from Pocahontas. This would be cheaper to construct than the road laid out, although I think that a good road to the springs along any route would be more expensive than is generally supposed. From Pocahontas a road is already constructed about five miles toward the springs. This has been constructed to be used in hauling out timber for the Jasper park collieries. This road could be improved and used as a part of the route to the springs. However, the part between the end of this road and the springs is the difficult part to construct. The present road could be produced to the mouth of Morris creek and thence along Fiddle creek to a good crossing and thence across that creek to my location on the east side, and my location could then be used to the springs. I think this would be the best route, if the road is to start at Pocahontas, because, by following the west side of Fiddle creek, a large number of creeks and gullies would have to be crossed where the hillsides are steep and the nature of the ground is such that landslides and washouts would be liable to give trouble. It would, however, necessitate two bridges across Fiddle creek. There is a fall of four or five feet in Fiddle creek, a short distance below the mouth of Morris creek. Here the river bed is narrow, and a bridge could be easily constructed over the falls. Or probably some more suitable crossing could be found between Morris and Villeneuve creeks.

The route above described would not include the scenery around Fiddle creek canyon, but a branch road could be built from some point on this road to the canyon. This route could, however, be made to include the "Punch Bowl" falls, a short distance from Pocahontas, and probably a very pretty falls, 25 or 30 feet high on Morris creek, about a mile above its mouth. This route would undoubtedly be cheaper than the route I laid out by Fiddle Creek canyon. But, if constructed, the hotel site would have to be changed and some point in the vicinity of Pocahontas chosen. There are two reasons for this. In the first place the distance from the present site to the springs by that route would be too great, and in the second place, if the present site were used, Fiddle creek would have to be crossed to go to Pocahontas, and to bridge Fiddle creek below the canyon would be impracticable. The bed is too wide, and at flood times the creek spreads over the whole bed.

The part of the road already constructed from Pocahontas climbs to the top of a divide. From there it would have to be run down again through an elevation of over 400 feet to cross Fiddle creek, and of course this elevation would have to be climbed again. Almost all such extra climbing would be avoided on the route by the canyon. The route from Pocahontas would also be longer than the canyon route.

By whichever route the road is constructed, there will be considerable clearing to do on the right of way, as almost the whole country is covered with brulé. In many cases this brulé is intergrown with small jackpine, and trees over eighteen inches in diameter are quite frequent.

I may say that the contour work which I did was done with a view to locating a road from the present proposed hotel site to the springs so as to include the scenery around Fiddle creek canyon on the route. I had no time for any other. However, some of this and some of the work done by Mr. Herriot in 1911 would be useful in investigating other routes.

I consider that the canyon route, along which I made my location, would give the best road, both for roadbed and scenery, also for grades. But I think a cheaper road can be built from Pocahontas. From my plan and profile and accompanying notes, an estimate can be made by an engineer as to the cost of construction by the canyon route.

I completed the location of the road on September 28. I then moved my outfit by wagon and pack horses to Hinton, and took train to Thornton where I was instructed to make some subdivision surveys near the headwaters of Wolf creek, to tie in a location line of the Canadian Northern railway.

At Thornton I hired pack horses to supplement my own pack outfit and, on October 5, I left there, following a trail which runs along Wolf creek up to its source and thence southerly towards the Pembina and Brazeau rivers. The trail also follows close to the Canadian Northern railway location lines. Although generally good, this trail passes through some bad muskegs, which gave me considerable difficulty on my first trip from Thornton, and the horses were mired many times. After the first two trips over the trail, the weather became cold enough to freeze the muskegs.

I established my first camp in township 50, range 18. This was not within the area to be surveyed, but some of the lines to be surveyed were accessible from this camp and I decided to start work from there, because I arrived late at night, and I did not think I had enough supplies to spend another day on the trail. The following day I sent the packers back for more supplies.

My last camp on this work was near the place where Wolf creek crosses the thirteenth base line. From this camp a return trip to Thornton by pack horses occupied about eleven days. As practically all the horse feed had to be hauled from Thornton, I found it almost impossible to keep up supplies by pack train, so I decided to use flat sleighs. I started using three sleighs about the middle of December, travelling on the ice on Wolf creek as much as possible. I found that I could haul more on three sleighs than my eight horses could pack, and also found flat sleighs a very satisfactory means of transportation, especially when they can be used on the ice on lakes or rivers.

The country surveyed consists mostly of ridges with shallow muskeg between them. The land on the ridges is more or less sandy, often sandy loam. Some ridges are very sandy and grow no timber but jackpine. The subsoil in the muskegs is, of course, similar to the ridges. Many of the muskegs could be easily drained and would make the best of land. The timber found consists of spruce, jackpine, tamarack, some poplar, balm of Gilead and willow. There is very little timber of commercial value, because in the past forest fires have been too frequent to permit of a large growth. Both ridges and muskegs are timbered.

Very little game was seen, except grouse and rabbits, althugh moose tracks were seen. The rabbits were very numerous, and it was common to see hundreds of them around camp at night. They were very destructive, and would even eat tripods and axe-handles. I do not think that fur-bearing animals were numerous, as no trappers were operating in the area surveyed, except a few Indians, who spent only a few days and passed on. Trappers operating in the vicinity find lynx to be the most profitable fur-bearing animal in the district. Weasel are also found and trapped, and there are also muskrats in the lakes and streams.

I made surveys in township 50, range 17, and townships 48 and 49, ranges 16 and 17, west of the fifth meridian, but I was not able to complete all the work for which I had instructions. On December 28 my packers arrived in camp on their first trip with flat sleighs, with a load of supplies. They were delayed on the road from Thornton

because they had to cut out much timber which had fallen across Wolf creek since flat sleighs were last used on it. In the mail which I received there was a telegram ordering me to close operations at once. As my packers had just brought in a load of supplies, I could not take back this load and all my camp outfit at once, so I sent out half of my party and left the remainder to complete the mounding . After the first half of the party arrived in Thornton, I disbanded the men, and sent the packers back for the rest of the outfit. The remainder of the party arrived in Thornton on January 28, 1913, and I disbanded them, retaining only the packers to take the horses to Ray, Alta., where they were wintered with Mr. A. McDonnell. On February 6 I left Edmonton for the East.

APPENDIX No. 34.

ABSTRACT OF THE REPORT OF P. MELHUISH, D.L.S.

SUBDIVISION SURVEYS IN THE KAMLOOPS DISTRICT OF THE RAILWAY BELT, BRITISH COLUMBIA.

After receiving my instructions, I left Vancouver on May 11, 1912, for Spuzzum, to make surveys in township 8, range 26, west of the sixth meridian, and to survey timber berth No. 552. The first camp was made in section 36, near Spuzzum station, which is on the main line of the Canadian Pacific railway, about 114 miles east of Vancouver. As the old Yale and Cariboo road is entirely obliterated in a great many places along the Fraser canyon, the railway is the only means by which the northerly half of this township can be reached. This road has, however, been repaired in places to a certain extent by the Canadian Northern railway contractors and it is possible to travel by wagon from Yale to a siding known as Saddle Rock, in the southern part of the township. All the agricultural land is included in Spuzzum Indian reserve No. 1 and a few small flats outside the reserve hardly large enough in area to be considered profitable. These small flats are adjacent to the Canadian Pacific railway line and the rest of the land in the township lies on steep mountain sides, timbered with fir and jackpine, and entirely unsuitable for agriculture. No minerals of economic value were found in the township.

The next camp was made in lot 4, near the mouth of Spuzzum creek. This creek is the only one of any considerable size in the township. It flows in an easterly direction and empties into Fraser river in section 24. While working from this camp a trail was made up the left bank of Spuzzum creek. An old trail was found, but it was necessary to cut parts of this out again and to do some mattock work on the steep side-hills. After finishing the subdivision work, camp was moved up the creek in order to continue the survey of timber berth No. 552. This berth is situated in townships 8, ranges 26 and 27, and township 9, range 27, west of the sixth meridian, and lies on each side of the valley of Spuzzum creek. The berth was surveyed to include all the available timber of value not already taken up, for a distance of about eleven and a half miles from the mouth of Spuzzum creek up the north fork, and about nine miles from the mouth of the creek up the south fork. The area of the timber berth is about 4,470 acres. Spuzzum creek is a swift mountain stream with an average depth of about three feet and a width varying from half a chain to a chain. The bed is very rough and is composed of large granitic boulders. The mountains slope towards the creek at a very steep angle on each side, and for a distance of about three-quarters of a mile from where the Canadian Pacific railway crosses, the water runs through numerous small canyons. The elevation of the main forks, which are about six and a half miles from the mouth of the creek, is 1,200 feet above the Fraser. The highest falls, however, are only about twelve feet, and there is hardly sufficient water during the dry period to warrant the construction of a dam.

The old trail which we found followed the general direction of the creek from the railway line as far as the main forks. A new trail was cut out from the main forks to the second forks, on the north branch of Spuzzum creek, a distance of about four and a half miles. Another trail was made up the south fork a distance of about two miles. All the transportation up the creek was done by man packing; more work would be necessary on the trail to render it suitable for pack-horses to travel on.

The berth contains some good cedar, fir and hemlock, most of which is near the creek, but it will be difficult to get it out. The timber becomes scrubby and generally

rotten on the inside at a distance ranging from twenty to thirty-five chains from the creek

As far as the berth extends, no minerals were found, but farther up the north fork graphite has been discovered, and there seems to be a possibility of this being mined in the near future.

Bears, deer and mountain goats are found in the mountains near the creek, and brook trout are plentiful.

The survey of the berth was finished on September 19, and it occupied two days for the party to move the outfit down to the railway. The next work was the survey of the northwest quarter of section 36, township 7, range 26. There is a small flat in this quarter section which contains about five acres of agricultural land which could be irrigated from Fivemile creek.

After finishing the survey of this quarter section the party was moved to North Bend by rail, to make surveys in townships 10 and 11, range 26, west of the sixth meridan. There are five or six settlers in township 11 who have taken up lands on the sloping benches. These lands are timbered with fir, birch and alder, and in parts are easily cleared. Two settlers on the east side of Fraser river have taken up quarter sections in sections 14 and 23, where there is some good timber which would be suitable for ties. No difficulty was experienced in crossing the Fraser about two miles above North Bend by means of an Indian dug-out canoe.

A wagon road is being built by the British Columbia Government from North Bend to Chaumox, a distance of about five miles along the Canadian Pacific railway. This road will allow the settlers to haul their produce to North Bend, which is a railway town, with car repair shops and yards for making up freight trains.

There are several creeks suitable for irrigation purposes in township 11, but none large enough for generating electric power.

After finishing the work in township 11, somewhat over three miles of line were run in township 10, where a tie was made to the Canadian Pacific railway right of way. The lines in this township were over high rugged mountains, and ran round an Indian reserve and two small farms.

The next work undertaken was at Keefers in township 12, range 26, where the party was moved by rail on November 21. Camp was made opposite Keefers station, and slight trouble was experienced in obtaining wood. The work undertaken lay in section 30 on both sides of the Fraser, which was crossed by means of the cable owned by the Canadian Northern railway contractors. There is a small area of flat land on the east side of the river in section 30, but it would require considerable clearing, and the soil is too rocky to be profitable. It contains some good fir for tie timber.

The country seen during the season in townships 7, 8, 10, 11 and 12, range 26, is all mountainous. The most desirable land was in township 11, where settlers will, after clearing their land, be able to market their produce with no trouble. The land in all these townships requires irrigation, and after this is effected vegetables and fruit of good quality can be raised.

The grading of the Canadian Northern railway which runs on the east side of the Fraser through these townships is nearly finished, and work on the bridges and culverts is being rapidly pushed ahead. It is expected that the railway will be open in 1915, and when the progress of the past year is considered this seems quite feasible, even considering the difficulties encountered in the Fraser canyon.

There are no summer frosts in the country covered by the season's work. The first frost was on October 14, and the climate generally does not run to extremes. There is considerable rain in the North Bend country during the late autumn, but in the summer the climate is dry except in the high mountains. No minerals of any value were found, and no coal-bearing formations were seen. Bears, deer and mountain goats are plentiful at a short distance back from the railway, and salmon are

caught by the Indians, some of whom rely on this to some extent for their winter food. Grazing land is scarce, and the only cattle we saw did not appear to be in good condition for wintering.

The transport arrangements were effected by means of the Canadian Pacific railway and by hiring locally a team and wagon, as required.

The party disbanded at Keefers on December 3 owing to the difficulty of working on the mountain sides with snow on the ground.

APPENDIX No. 35.

ABSTRACT OF THE REPORT OF C. F. MILES, D.L.S.

MISCELLANEOUS SURVEYS AND INSPECTION OF CONTRACTS IN ALBERTA AND WESTERN SASKATCHEWAN.

My work during the past season consisted in the survey of timber berth No. 1900, and a settlement and Roman Catholic mission at Green lake, and the inspection of contracts Nos. 14 and 33 of 1911, and Nos. 21, 22, 24, 25, 29 and 30 of 1912, in the province of Saskatchewan; also a reinspection of contract No. 14 of 1910, in the Cold Lake district in Alberta.

We left Edmonton on May 18, 1912, and followed the trail through Fort Saskatchewan, Bruderheim, Saddle Lake and St. Paul de Metis to Cold lake, a distance of about 200 miles. I commenced the survey of timber berth No. 1900 on May 28 and completed it on July 4.

While camping along this lake, we tried fishing with a net and caught whitefish up to six pounds in weight; we also caught salmon trout up to eight pounds in weight by trolling.

There is some excellent spruce on this limit, the best and largest, up to three feet in diameter, growing on the southerly part. There is also reported to be very good timber along the river that runs from Primrose lake into Cold lake.

A good deal of smoke was observed on the north and west sides of the lake during my stay there, but what damage was done by the fires I could not ascertain. Fires also entered the berth I was surveying from the east, but did no appreciable damage to the timber, at least not while I was in the vicinity. The most damage was done amongst the smaller trees along the shore of the lake, where the high winds off the water kept the fire moving. Fires were also seen along the west shore all the time I was camping on the lake, and were said to have been started by settlers and Indians in order to increase the area of their clearings. At one time the fire came in our direction, and we had to bundle everything into two punts and get out of its way.

On July 5 my outfit left French bay on Cold lake for Green Lake settlement by way of Frog lake, Onion lake, St. Walburg and Meadow lake, a distance, by section lines, of about 230 miles. We arrived there on the 25th after having, on the way, inspected the greater portion of contract No. 14 of 1911.

Settlement ceases about ten or twelve miles north of St. Walburg, and after crossing Fifteen-mile creek, we travelled through thick woods all the way to Rabbit creek, where there is a stopping place near where trail we had been following joins the one that leads directly from Makwa lake to Meadow lake. No more settlement was seen until we got within seven miles of Meadow lake, where we found some fine stretches of park-like country partly settled by a few French half-breeds, who are engaged in farming to a small extent, and in raising cattle and horses.

Beyond Meadow lake and along the trail to Green Lake settlement new settlers have come in, who are also engaged in cattle raising. They were cutting large quantities of hay in the flats of Meadow river. This river empties into Beaver river, which has low banks below the junction. Here also much hay was being made for herds of cattle brought in from the south, where herd law is in operation.

Green Lake settlement is inhabited by a number of old French half-breeds, some of whom have resided there for many years, and most of whom are old employees of the Hudson's Bay Co. They support themselves by farming on a small scale, having

small clearings of two to ten acres. They have a few head of cattle and horses and, besides, are engaged in freighting, fishing, hunting and trapping. A fine church forms the nucleus of this settlement, which is presided over and served by a French Roman Catholic priest, who is also the postmaster and general adviser to the community. The Hudson's Bay company have an old established post there, as also have the Revillon Bros., a French concern with headquarters in France and Edmonton. Telegraph connection with the outside world is maintained by way of Battleford, and was successfully inaugurated during the past year. Trails from there lead to Prince Albert and to Battleford. The nearest railway is the branch of the Canadian Northern from Big River to Prince Albert, the distance to Big River being only about 50 miles by the canoe route.

I finished the survey of settlers' claims and the inspection of contract No. 14 of 1911 on August 17, and then left for contract No. 33 of 1911 by way of the Meadow lake and Makwa river trails. I crossed Horsehead creek on August 21 and commenced the inspection of that contract. There are several settlers along this trail. All engaged in ranching, and hay meadows appear to be plentiful. Some settlers from the vicinity of the Saskatchewan were cutting hay there, and intend driving up their cattle to winter them on Red Willow lake in township 58, range 21, west of the third meridian. On Meadow river, too, we met one outfit that had driven in over 300 head of cattle, and the men were cutting hay and putting up buildings with the intention of wintering there.

We finished the inspection of the contract on September 3 and moved south on the following day. There were heavy rains about this time and we were held up about fifteen miles from St. Walburg on that account.

From St. Walburg we drove by way of Onion lake and Frog lake to Cold lake in order to make a second inspection of contract No. 14 of 1910. I was getting very short of men and tried to hire some, both at North Battleford and Lloydminster, where I had gone to procure another supply of provisions, but without success.

On September 14 we arrived at Cold Lake post-office, where I succeeded in hiring a couple of Indians. We completed this reinspection on September 23, and left for Mervin the following day.

I returned to Lloydminster and North Battleford to secure some more help, but I had little success, as I secured only one man. I left the latter place on October 7 and rejoined the party at Mervin.

It strikes one as peculiar that north of the Saskatchewan there are so few cattle; thousands of acres are available for pasture, but no cattle are found. This I learned is the result of "herd law." If homesteaders would only fence in their little patches of crops, cattle might run at large and grow fat on the almost unlimited pasturage. As a rule, however, the homesteaders come in, do some ploughing, sow a little grain, and leave it while they attend to some other business, returning probably about harvest time. In the meantime settlers who have any stock must either herd them or drive them up many miles to the north where the herd law has not yet been introduced. It is my opinion that so long as herd law prevails, mixed farming will have to be suspended, and the extensive areas of pasturage go to waste.

Leaving Mervin on October 12, we travelled easterly by a trail to New Mervin, the present terminus of the grade of the Jackfish Lake branch of the Canadian Northern railway Thus far we found the country fairly well settled, but along the trail east of Turtle river only a few settlers were seen. When we turned east on a trail that runs south of Turtle, Stony and Midnight lakes to Birch lake, quite a number of settlers were observed, engaged mostly in cattle raising. They were busy cutting feed, for winter use, in the extensive meadows near these lakes. We reached Kellogg's ranch on the west side of Birch lake on the 13th, and Birch Lake post-office the following morning. Continuing northeasterly for about six miles we passed about half a dozen settlers. We then entered the woods on the Pelican lake trail. Journeying

along this trail 15 or 20 miles easterly and northerly we re-entered meadows, which continue northerly about five or six miles up to within a mile or two of Chitek lake. There a quantity of hay had been cut. In that vicinity there is a small Indian village, comprising about half a dozen families, who fish, hunt and trap and make hay for their horses. No cattle were observed around the village.

We continued our journey by the Green lake trail, which we followed southerly until we struck Big river, in contract No. 21 of 1912, on October 17. We camped in that vicinity, there being a considerable area of open prairie to the west of Big river, Much of the land to the north of the river consists of muskegs and marshes and there is a good deal of open country, but bush and burnt wood lie south of the river. I completed the inspection of this contract on the 26th and started the following day on our return to Birch lake, where we arrived on the 31st, having experienced some delays on account of stray horses. While my party camped there preparing returns of the inspection, I drove to North Battleford to hire some men and to purchase another team and supplies.

We experienced the first heavy fall of snow on November 9 at Birch lake. I procured some sleighs and left for contract No. 24 on the 12th, passing along the west side of the lake, through a good deal of meadow land. We passed a number of hay stacks, where several hundred head of cattle were being held and fed. We arrived at the contract on the 14th, but we experienced considerable trouble proceeding along the trails opened out by the contractor. They were opened out for wagons, and I, having sleighs, was compelled to cut down a great number of stumps nad remove fallen timber; in one instance it took us three hours to go two miles. We commenced inspection of this contract on the 15th and completed it on the 28th. Considerable time was lost on account of my only transit being damaged by a fall, necessitating my borrowing a spare one from Mr. Robinson who was working in contract No. 24. On the 29th we had to break the ice to cross a creek running out of Long lake, and on the following evening was registered the first minus reading on the thermometer.

We arrived at Birch lake on November 30 and having received notice of the arrival of my sleighs from Edmonton and my transit from Agincourt Observatory, where it had been repaired, I sent a couple of teams to Meota on the Jackfish Lake branch of the Canadian Northern railway to get them. The teams returned to camp with the sleighs on December 5 and on the 7th we started off again on the trail for Chitek lake to inspect contract No. 22, where we arrived in section 21, township 54, range 12, west of third meridian on the 9th. From there we travelled up the Green lake trail to the northwest quarter of section 31, township 55, range 11, and after retracing a block there we moved southerly to section 9, township 53, range 12, where we retraced two blocks, completing the inspection of the contract on December 21. We then started on our return trip to Birch lake.

So far as I am aware no cultivation of the soil has been carried on in this part of the country, and I would judge that the open parts would be better adapted for the raising and feeding of cattle, than for the growing of cereals. We found much jackpine and spruce throughout the more northerly part of this contract, but these do not by any means indicate a good farming country.

We returned to Birch lake on December 24 and, leaving my outfit there, I drove to Meota and thence by train to North Battleford in order to purchase some supplies.

I returned to Birch lake on December 28, and left there with my outfit on the 30th for the inspection of contract No. 25 of 1912. We travelled northwesterly over a good deal of meadow land to Midnight lake, crossing to the west side of the lake, on the ice. · About half a mile farther west we struck the new provincial Government road to Meadow lake. This road is said to have been greatly improved during last summer, all the soft places having been corduroyed; it makes a good sleigh road now, and possibly may be a fair summer road too.

I reached this contract on January 1, 1913, and on the following morning moved to the northeast quarter of section 2, township 56, range 16, west of the third meridian, and camped on the north side of a lake. From there we retraced two blocks in townships 57 and 58. Like the other townships inspected last fall and winter, muskegs appear to abound; the surface is divided up into muskeg, jackpine ridges and poplar groves of less or greater extent, the first or second of the three predominating in the various townships. The latter indicates the better class of land, the first the richer soil, and the second generally consists of light sandy soil. It is my belief that this section of the country will ultimately become a good cattle country after repeated fires have cleared off the timber

While camped in this district our thermometer for the first time during the winter registered lower than 40° below zero; in fact at my camp it was 44° below and at the contractor's camp about four miles north, 47° below. From this camp I moved across the lake and from there cut a trail south through about four miles of muskeg.

Rabbits were more plentiful in this district than I had ever seen them in my fifty years of survey experience, but they were afflicted with some disease, and were dying off by scores. At one place where we camped about four days, eight dead rabbits were found behind the tent when we removed it. Invariably when I left my tent to go to the cook's tent for a meal, half a dozen of them would be found in it on my return, sometimes one or two of them dead.

On January 12 we started out for the Government road, and on the 13th drove south past Midnight lake to Stony creek, which runs from Midnight lake to Stony lake. On January 18 we started westerly by way of Stony, Turtle and Island lakes for Brightsand lake, over trails that had not been broken and which were therefore rather heavy travelling in the open places. Generally the north and south trails communicating with the railway are well travelled, but the lateral trails in winter are but little travelled and when the snow comes to any depth they are very heavy.

We arrived at the southwest quarter of section 20, township 53, range 20, west of the third meridian, on January 21, and camped on the west shore of Brightsand lake, and on the 24th we left for Redwillow lake in section 17, township 58, range 21, west of the third meridian. There we traversed the lake, which formed a part of contract No. 33 of 1911. On the shores of this lake were domiciled some parties from the vicinity of Saskatchewan river who had driven in their cattle during the summer, cut hay and were wintering them. The hay is mostly slough hay, but the cattle were apparently thriving on it. In the spring these parties intended to drive their cattle south again to their homesteads. North of this we saw no more settlers' outfits but we saw some Indians, some of them living in houses, in the vicinity of which they had been putting up hay for the few horses they own. We travelled north as far as section 4, township 63, range 20, in contract No. 30 of 1912. Up as far as Beaver river we found recent Indian sleigh tracks, but after that we found it much heavier going, the snow becoming deeper. The immediate banks of Beaver river in this vicinity are not nearly so high as those twenty or thirty miles farther west, where they measured 200 feet or more. The banks of the Waterhen, where we crossed on the ice, are low, the river itself being about 5 chains wide, and apparently shallow. Farther down, the river widens out, the immediate banks being only a foot or two above the level of the water, and probably twenty chains in width. On both sides lay what appeared to be strips of meadow making a total width of probably half a mile. The river is shallow, as at various places where we had to cut through two feet of ice to water the horses, the depth of water generally was not more than a couple of feet below the ice. In one or two places we found a small quantity of hay cut by the Indians, also a stable and a few isolated shacks. The country generally appears flat and is timbered with poplar, spruce and tamarack, with dense willow in places. The general appearance strikes one as being that of a country best adapted for cattle raising. We passed various Indian hunting and trapping camps, where they had apparently fish and meat

Photo by G. H. Blanchet, D.L.S.

Grand Rapids on the Athabaska. Loon River Entering on Right.

Photo by E. Deville, D.T.S.

Road Construction at Banff.

in abundance. Moose and deer are very plentiful, the former being observed almost daily, and judging by their tracks in the woods, the Indians would have no difficulty in procuring a good supply of fresh meat.

From contract No. 33 we moved along Waterhen river down to contract No. 29, and then struck south to Beaver river, where we inspected two townships. By this time the snow had fallen to such a depth that we found it somewhat difficult to make satisfactory headway, the trip from the Waterhen down to the Beaver occupying a whole day. I therefore concluded to bring my season's work to a close. Travelling along the Beaver for a few miles we found it flooded, the weight of the snow having brought the water up on top of the ice. I then decided to strike out by the shortest way to the Meadow lake trail. We arrived at the Meadow Lake post on February 18. After purchasing a few necessaries at the Hudson's Bay company's post we started on the trail which was fairly well broken, and arrived at Brightsand lake on the southwest quarter of section 20, township 53, range 20, on the 21st. There I made arrangements with Mr. Ole Thorson to winter my outfit. I arrived in Battleford on March 1 and paid off the men on the 3rd. I reached my home in Toronto on the 8th.

APPENDIX No. 36.

ABSTRACT OF THE REPORT OF J. B. McFARLANE, D.L.S.

SURVEY OF PART OF THE FOURTH MERIDIAN AND OF PART OF THE TWENTY-FOURTH BASE LINE WEST OF THE MERIDIAN.

During the summer of 1911 I had run the fourth meridian as far as the north-east corner of township 105. As this point was too far north for me to attempt to pack the outfit and supplies from Clearwater river, an attempt had to be made to reach it from the north, that is, from Athabaska lake, and to work from a cache to be located or some portion of the lake. With this purpose in view all possible inquiries were made when I was at McMurray in 1911 about the country between the end of the line and the lake. However, little was to be learned except from the Indians, and their answers are nearly always ambiguous.

I left Edmonton on May 3 with my party and outfit, shipping a car to within eight miles of Athabaska Landing. From there the outfit, supplies and oats for feed had to be freighted to Athabaska Landing. I left the latter place with two scows on May 8. My pack horses which had wintered at Ray left Edmonton on May 2 but I had been entirely misinformed about the time taken to reach McMurray by trail and I had to wait considerable time for these horses. On June 3, I placed a cache at the cascades on the Clearwater for work on the twenty-fourth base line and for the trip out. Then returning down the Clearwater I took the outfit and supplies down Athabaska river to Athabaska lake and thence across to Old Fort river and built a cache about three miles up that river. I had learned at Chipewyan that this was the river which ran along the meridian in township 105, so I chose this spot for the cache as it was convenient to all parts of the proposed line. Here there was another wait of a few days for the horses which were taken to the fourth meridian from McMurray by the trail along the twenty-third base, and thence up the meridian trail and down Old Fort river to its mouth. The outfit was packed up this river and work commenced on the meridian on July 2. The horses had travelled over six hundred miles by land and the outfit by land and water about the same distance before any line was run.

The country through which the fourth meridian was produced in 1912 is much more valuable than the land through which it was run the previous year. The elevation is lower and grass is much more plentiful, and much of the land will be available for ranching. River and creek valleys have good grass in them and considerable scattered grass is found among the hills. This was not the case with much of the land to the south where we had to depend on beaver meadows for horse feed.

The country through townships 106, 107, 108 and the south half of 109 is in general much the same, consisting of rolling or undulating sand hills covered with small jackpine and brulé, and dotted with small lakes, some of which have no outlets. A small proportion of the land is stony. The water in the lakes is generally good, and many of the larger ones have sandy shores. The valley of Old Fort river follows the line closely through these townships and it becomes deeper and narrower farther north. It is nothing more than a large creek in township 105, but it is joined by Beaty river, which is of about equal volume, in the middle of township 106, and is then except at some rapids, too deep to wade. The narrow river flats are generally covered with grass and willow. In township 108, Douglas river, a stream 100 feet wide and three feet deep with a rapid current, joins the Old Fort, and the latter, from there down, would be navigable for scows except that the rapids are too numerous and too

long. In this township the river turns west for about ten miles and then north again. There are no tributaries of appreciable size on the west bank of the river, as a range of hills about five miles west of the river seems to form a watershed. These hills extend to the north to Old Fort point. All timber is kept burnt off or stunted by forest fires which appear to burn regularly and systematically. Back from the river and its tributaries the land is more level. In the centre of township 107 a large muskeg crosses the line and stretches away to the east. The muskegs are valuable in that they have kept the accumulation of soil from being destroyed by fire, and when drained they may become fertile lands. The timber on these is stunted and of little value.

From the middle of township 109 north the surface of the country is quite different. Muskegs cover a large proportion of the land. The pack trail which was chosen so as to avoid these is about twice the length of the line. In the north of township 109, a shallow lake, a mile wide by a mile and a half long, lies across the line. It has a muddy sandy bottom and the entire lake is dotted with water lillies and weeds. A creek one hundred feet wide, and with very little current, flows in at the east end. It resembles the lake in bottom, depth and vegetation and, like the lake, has a stretch of muskeg and swamp on both sides. The outlet of the lake, Harrison river, flows through a swampy flat containing another small lake, then enters a rolling stretch of country, where the river has some rapids. North of the shallow lake the line continues in muskeg to section 25, township 110. Some of this muskeg has been burnt over and, in places, thick grass three feet high had grown on the brulé. I believe that these lakes and this muskeg which stretches away to the northeast could be drained and made into a fertile flat containing an area about equal to a whole township. North of this muskeg the line crosses a range of rolling sand hills about two miles wide, then a creek flowing west to Harrison river runs through a narrow meadow across the line. This creek has its rise in innumerable lakes and wide stretches of muskeg to the east. North of this the line crosses an elevation covered with boulders, then about two miles of muskeg, while the pack trail follows rocky ridges, probably a series of moraines, to the northeast. These ridges are cut off by small muskegs in all directions. From the middle of township 111 to the north of township 114 the country is a succession of stretches of muskeg from a few chains to a mile or more in width held in by ridges of sand or sand and boulders, or occasionally by some low rolling sand hills. Lakes are numerous and are of all sizes up to several miles in length. The longest triangulation during the season was two miles in township 114. The creeks are all small through the above stretch of country and meadows are scarce, but some of the lakes have slough grass in bays and around the shores. A well-beaten Indian trail from Old Fort bay crosses township 112, striking the meridian near the northeast corner of section 25. Thence it goes on easterly among lakes and muskeg, where it soon becomes indistinct. The only marked valley near Athabaska lake is that of a large creek which crosses townships 113 and 114 in a northwesterly direction. Through these townships the valley is about one hundred feet deep and a mile to two miles wide. When this creek enters township 115 it flows west about three miles down a number of rapids in a narrow ravine, crosses the line, then turns north with only a range of sand hills between it and the lake, and recrosses the line at the northeast corner of section 1, township 115. It enters the lake proper about a quarter of a mile east of the line, but recrosses the line again on the three-quarter mile sand beach. On section 1 the creek flats are about twenty to thirty chains wide and a beautiful hay meadow lies along the creek. There are also several smaller meadows up the creek. This stream is about eighty feet wide and two feet deep, with a current about one and one-half miles per hour. The land to the northeast of this creek is fairly level and dry, covered mostly with jackpine. A fire burnt over most of townships 114 and 115 early in the summer of 1912.

A great deal of red sand was seen through this country but there is not enough iron in it to form an ore.

By September 10 the meridian was run to Athabaska lake and we were ready to move back along the meridian to the twenty-fourth base line, but part of the pack train had made a trip down the meridian to township 102 with supplies for the long trip. These arrived back at the lake on the 13th, and on the following Monday we left the camp on the meridian at the lake and travelled south by the sandy beach of the lake, as this was excellent travelling and much shorter than the pack trail up the line. Good feed was found on a small hay meadow at the mouth of Harrison river at Stone point. When we reached the point north of Old Fort bay the horses were sent around the bay and the outfit was taken across the narrow neck of water on a scow.

The most beautiful hay meadow I have ever seen lies on the point just west of the mouth of Old Fort river. The hay stood from three to five feet high and grew thick on the ground. The area would probably be about two square miles and although willow encroach on the southern part, the northern part is very clear. The water in Athabaska lake was much lower than in June, and on the main shores there is a beautiful sand beach a quarter to a half mile wide, broken only by a few narrow stony points. In the Old Fort bay this beach was a muddy sand with poor vegetation.

On September 23, we left the cache on Old Fort river and moved down the river to the fourth meridian reaching the twenty-fourth base line on October 7. A pack trail had to be cut across range 4 so that work was commenced on the base line on the 14th.

Through ranges 5 and 6 the line lies in undulating and rolling country consisting of sandy ridges and hills with muskeg between. A fire overran most of this country early in the summer of 1912 and killed most of the timber on the dry ground and burnt through some of the muskegs. A patch of twelve-inch poplar on section 33, township 92, range 5, and many sixteen-inch spruce scattered along ridges in sections 1, 2 and 3, township 93, range 5, were fire-killed. The creeks in these townships are small, have a good fall and drain in general to the southeast. On November 4 the line reached the middle of range 6, and my assistants and men refused to go any farther west on the base line, consequently I was forced to quit work for the season, although it was not yet possible to travel out on the ice.

Levels were run throughout the season, work commencing from bench-marks established in 1911 and using the elevation then given them. Levels between each two bench-marks were checked by a separate line of levels. The elevation at the northeast corner of section 36 township 105, range 1, west of the fourth meridian, is 1260 feet. This soon drops to the north as the line enters the valley of Old Fort river. Most of the north part of township 106 and practically all of township 107 lies between 1,100 and 1,200 feet. In townships 108, 109, 110 and 111 the elevation varies around 1,100 feet, local depressions going over 50 feet below, but little change in the general elevation. In township 112 the average elevation drops about 50 feet and township 113 is very level, with an average elevation of about 1,025 feet. The south half of township 114 is about 1,000 feet, but the north half gradually drops to below 900. In township 115 the elevation drops to 843 at the first crossing of the large creek, then rises to 871 to drop again to 842 at the second crossing of the creek. The sand bank between this and Athabaska lake rises to 898 feet. The ordinary high-water mark was 848 feet and the water level on September 9 was 840 feet.

On the twenty-fourth base line the elevation gradually drops quite uniformly across range 5 from 2,255 feet at the east to 1,898 at a creek about the middle of section 31. From that point there is a gradual rise for two miles till an elevation of 2,023 feet is reached. The elevation is about 2,000 feet on an average for the last mile and a half of line run.

By December 5, Clearwater river was frozen sufficiently to travel on and we left there on that day by the winter trail to Big River settlement, and reached Edmonton on December 25.

APPENDIX No. 37.

REPORT OF GEO. McMILLAN, D.L.S.

SURVEY OF THE TWENTIETH BASE LINE WEST OF THE FOURTH MERIDIAN.

FINCH, ONT., January 27, 1913.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa, Canada.

SIR,—I have the honour to submit the following general report on my survey of the twentieth base line west of the fourth meridian, during the season of 1912.

I left Ottawa on April 10 and, after outfitting in Edmonton, I hired two teams and left for the work on April 29, my supplies having been forwarded during the winter by Mr. J. N. Wallace, D.L.S. The route followed was by Fort Saskatchewan, Bruderheim, Star, Wostock, Whitford lake, Pakan, and Beaver river to lac LaBiche. Another route that might have been taken thus far was by Athabaska Landing and then eastward to lac LaBiche, but by the latter the roads are said to be bad during the spring season.

On May 11, I reached Spencer's ranch at the east end of lac LaBiche where the wagon road ends; the two freighters were sent back and our own horses were packed from there. From Spencer's we travelled by the pack-trail leading to McMurray as far as Sandy lake in township 74, range 11, and then by a hunter's trail that passed near the cache located last winter by Mr. Wallace. The cache was near the middle of township 76, range 11. From there to the starting point of our work, a distance of about ten miles we cut our own pack-trail and reached our destination on May 24. The weather was cold and there had been no growth; consequently, the horses were beginning to fail for the lack of grass.

On May 27 we began work on the base line by offsetting the northeast corner of range 10, a distance of 3.02 chains to the north, and then producing the line westward from that point.

In range 10 the surface is low and a considerable part of it has been overrun by fires so that much of the timber is fire-killed. The green timber is small and of little value. The first appearance of grass was about June 1 in the valley of May river near the beginning of the range. This was a great treat for the horses as they subsisted for sixteen days on dead grass and leaves. There are some small meadows and blueberry patches in this range.

Townships 75, 76 and 77, ranges 11 and 12, are mostly covered with muskeg, and the natural drainage is not good. These townships are timbered with small spruce, jackpine and tamarack, the soil being almost valueless as a timber producer. Some good grass grows along the lakes and streams, but nowhere else. The surface of township 78, ranges 11 and 12, is higher and timbered with small jackpine poplar and spruce. The soil is light and sandy and not fit for agricultural purposes.

Range 13 is rolling and timbered with spruce, jackpine, poplar, willow and alder, and contains much windfall. The low land is too wet to be utilized and the high land too light and sandy for agricultural purposes. It serves a good purpose, however, in growing timber. Ranges 14, 15, 16 and 17 are well timbered and they contain a large percentage of good agricultural land. Some of the timber is suitable for milling purposes and pulpwood. There is an abundance of blue-joint hay.

House river crosses the line in range 14; it is the largest stream met with during the summer, except Athabaska river. It is about one chain wide, flows very swiftly in places and varies in depth from six inches to two feet. The banks are low and the soil adjacent is loamy and rich, and supports a heavy growth of grass. This locality is suited to farming and stock raising and plenty of hay can be procured, but at present the lying timber will not permit of the operation of farm machinery. It is, however, good grazing land with a permanent supply of good water.

The location survey of the Alberta and Great Western railway, and also the sleigh road used by the railway company in forwarding their supplies, are intersected in section 32, range 15. This sleigh road follows the muskegs and open swamps and is adapted for winter use only.

Athabaska river was crossed in section 31, range 18; it is twenty-seven chains wide and about twelve feet deep in low water, with a valley 104 chains wide and 370 feet deep. Both slopes are densely timbered with second-growth poplar, large black poplar and some fairly large spruce. The soil is a clay loam and from it ooze numerous small streams and springs which seem to be alkaline. The water from those springs was the only impure water met with all season. Athabaska river is navigable for flat-bottom steamers as far down as Pelican rapids, in township 80, or thereabouts. Scows laden with merchandise for the far north and others with settlers' effects were seen floating down almost every day while we were camped on the river.

For a mile west of Athabaska river there is a rim of firm soil but from there on to Pelican mountain, a distance of twelve miles, there is an uninterrupted muskeg. It was the wettest and most troublesome muskeg to cross that we encountered; almost the whole length of it had to be corduroyed or brushed that it might bear the pack horses.

From the end of range 20 to the end of range 26, the base line follows Pelican mountain. The surface is rolling and densely timbered with spruce, jackpine, poplar, balsam and birch of fair size. There is some milling timber and a great deal of smaller size, suitable for pulpwood. The soil is cold and sticky, and not suited for agricultural purposes. There are numerous small streams all flowing to the north and converging before leaving Pelican mountain. In range 26, these streams have valleys about 100 feet in depth but about three miles north when they have left the mountain, the banks flatten out. Townships 75 and 76, ranges 21, 22, 23, 24, 25 and 26 are more suited to raising timber than to farming, although much of the soil is too light and wet to grow anything but scrub.

To the north of Pelican mountain, in ranges 24, 25 and 26, there is a flat of good land suitable for farming when cleared. At present it is timbered with spruce, jackpine and poplar of medium size. This area is well watered, has a good natural drainage and is adjacent to two lakes containing whitefish. The sleigh trail from Athabaska river to Wabiskaw passes through township 78, range 24.

The facilities of transportation into the district crossed by the twentieth base line consist of the two winter roads previously mentioned, and Athabaska river, but none of these can be made use of during the entire year. The soil varies from sand to a clay loam, together with muskeg. There are two blocks already referred to where the soil should grow good crops after draining and clearing, and the remainder will grow timber.

To the east of the Athabaska the surface is rolling and to the west very rolling and hilly except on the muskegs. There are no prairie lands, as the surface is all timbered. There is very little high land scrub, but the muskegs are all scrubby. Sawlogs, ties and pulpwood can be procured on all the high lands. Hay of the blue-joint variety is plentiful in townships 75, 76, 77 and 78, ranges 15, 16, 17 and 18, and in a few other places. There is a permanent supply of water everywhere. There are no large water-powers, but a small amount of power could be developed on House river by the erection of dams.

The indications are that the climate will be suited to the raising of crops, although at present there are some light summer frosts. The rainfall is like that of eastern Ontario. Wood for fuel can be procured anywhere. No coal, lignite, stone quarries or minerals were seen, but oil development is in progress in some places along the Athabaska.

The game comprises moose, deer, black bears, foxes, coyotes, lynx, rabbits, partridges, ducks and geese; whitefish are caught in all the larger lakes.

I have the honour to be, Sir,

Your obedient servant,

GEO. McMILLAN, *D.L.S.*

APPENDIX No. 38.

ABSTRACT OF THE REPORT OF A. L. McNAUGHTON, D.L.S.

SURVEYS IN THE BRAZEAU DISTRICT.

On June 29, 1912, I left Edmonton for Coalspur on the Alberta Coal branch of the Grand Trunk Pacific railway, as this was the nearest point on the railway to my work, and on July 2 pitched camp in section 25, township 48, range 22, west of the fifth meridian, where our first work was located. Subdivision in townships 47 and 48, range 22, and townships 46 and 47, range 23, engaged the party until November 26. On the 27th the traverse of McLeod river was begun and, on the following day, my assistant left with half the party to finish some mounding in the vicinity of the Alberta Coal branch which had been left over from the previous season's work. With the remainder of the party I continued the traverse of McLeod and Beaverdam rivers, which I finished on December 9. On the 16th, the whole party, having completed all unfinished mounding, arrived at the twelfth correction line south of the Pacific Pass mines. On January 15, 1913, having finished our work in this vicinity, we returned to Mile 8 on the Mountain Park branch. From this camp three miles of the twelfth correction line was run, which finished the subdivision of all the country traversed by that branch. On February 1, we left for Edmonton where we arrived a few days later. Here I paid off and disbanded my party, and leaving Edmonton on February 10, arrived in Kelowna on the 12th.

The country covered by my work is reached by the Alberta Coal branch of the Grand Trunk Pacific railway. The Mountain Park branch leaves this line at Coalspur and, following a general southwesterly direction, enters the mountains twenty-four miles from that place, and terminates at the Mountain Park mines, eight miles farther south. Track-laying was begun on this branch on December 10, 1912, and I believe it is now well under way, and the road will perhaps be open for traffic during the summer of 1913. This gives easy access to the district in which most of my season's work is situated. The twelfth correction line south of township 47, range 19, is reached by a pack-trail running south from the Pacific Pass mines which are situated at the terminus of the Alberta Coal branch. There is a good deal of muskeg along this trail, and I believe it is somewhat difficult for loaded horses during the summer months.

The soil along the south boundary of township 47, range 19, is mostly a clay loam, which is very retentive of water. On this account, and because of the cold summer weather, it is of little value for agricultural purposes. The same observations apply to the soil along the northerly part of the Mountain Park branch. As one approaches the mountains the soil becomes more gravelly and the cuttings along the railroad generally alternate between gravel and solid or shale rock. In this district is found some of the best and cleanest gravel I have ever seen.

Foot-hills of varying height cover the whole district, surveyed, but the country in the vicinity of the twelfth correction line across range 19 is level to rolling, with a great deal of muskeg. The northerly part of township 48, range 22, is also rolling country, while southerly and particularly along the valley of McLeod river, the hills are higher and more rugged in appearance. McLeod river and the Mountain Park branch enter the mountains near the twelfth correction line. South of this line our work was somewhat more difficult and even dangerous, as the season was so far advanced that the slopes were covered with snow and ice.

Fire has swept over the greater portion of the district and consequently there is very little timber of commercial value. Along the north side of McLeod river, near the east boundary of township 48, range 23, there is a considerable area of green timber, spruce, jackpine and balsam which would be suitable for railroad ties. Timber of the same general quality was also seen along the twelfth correction line across range 19. I have been informed that fire-killed timber, if not rotted, makes the very best material for mine props, being much superior to green timber for this purpose. No doubt, therefore, use will be found for a small part of the dead timber which covers the country.

Good water is everywhere abundant in this country. Although McLeod river is very rapid, the character of the valley renders the development of water-power difficult. The most promising site for a power plant along this river is in township 47, range 23. Here the river, at one point, enters a canyon between two perpendicular walls of rock about thirty feet in height and about seventy feet apart. With small expense a dam could be constructed here and no doubt will be at some future date. At present the proximity of coal, capable of being cheeply mined, and the absence of any market for power render the project impracticable. One difficulty in the operation of such a plant would be the large quantity of frazil ice in the river during the winter months.

On account of the high elevation frost is liable to occur on a clear night during any month of the year. During my three seasons' experience in this district, I have seen snowstorms in each of the summer months. Rain is very frequent and during the latter half of August and the first half of September, scarcely a day passed without at least a shower. The fall weather, as usual, was very fine and no severe cold was experienced till about January 10, when we had sixty or seventy degrees of frost.

No outcrop of coal was noticed during the season, but several seams were seen in the cuttings along the Mountain Park branch. These were too near the surface to give any fair indication of the quality of the coal beneath. I did not have any opportunity to visit the Mountain Park coal mines, which lay outside my work, but have been informed that the quality of the coal taken out there is superior to that obtained in the foot-hills. Both the Yellowhead and Pacific Pass mines are now regularly shipping coal, and the indications are that this district will experience a steady growth in population and prosperity and will, in time, become one of the largest coal producing areas on the continent.

APPENDIX No. 39.

ABSTRACT OF THE REPORT OF E. A. NEVILLE, D.L.S.

SETTLEMENT SURVEYS ALONG SLAVE RIVER.

I organized my party at Edmonton, and from there proceeded to Athabaska Landing. For the transport of the party and outfit, I purchased a ten-ton scow and two canoes, and arranged to travel down the Athabaska from Athabaska Landing with the Hudson's Bay company's transport outfit. We left there on May 25, 1912, and on the 29th reached Grand Rapids, where we were delayed until June 5 awaiting the portage of the transport across Grand island, then continuing our journey we safely navigated the Brulé rapids. Upon reaching the Boiler rapids I hired a pilot from the Hudson's Bay company, according to arrangements which I had previously made with them. I also did this at the Long and at the Big Cascade rapids. All the remaining rapids were passed unassisted, following in the wake of the company's scows, and I finally reached McMurray on June 7. Owing to the company's transport being unusually large, I was forced to leave it behind and drift down the river. On reaching the mouth of Athabaska river, the heavy wind delayed me for a day, but as it calmed down in the evening, I effected the crossing of Athabaska lake during the night, and arrived at Chipewyan on the morning of June 16, two days ahead of the Hudson's Bay company's transport.

Chipewyan, with its rows of white houses, presented a very pleasing appearance when approached from across the lake. The rocky hills formed a picturesque setting, and the tepees of the Indians on their semi-annual visit added a touch of romance. The scattered tribes visit the settlements during June to receive treaty, and also come in at New Year to join in the holiday festivities.

The population of Chipewyan will average about two hundred, almost all of whom are engaged in hunting, trading and fishing. Scarcely any land is available for agriculture, but a few gardens are found between the rocky hills.

Following the instructions issued to me, I mounded the settlement of Chipewyan, which I completed on June 24, and the following day I departed for Smith Landing. I safely navigated the rapids in Rocher river, and proceeding down Slave river without any further interruptions, I arrived at Smith Landing on the 28th.

I was engaged for seven weeks in making the survey of this settlement, which extends about eight miles along the river. At the time of my visit the population was between two and three hundred, 95 per cent being Indians. The soil in the vicinity is first-class, consisting largely of heavy black clay loam which is ideal for the production of all kinds of farm produce, such as vegetables, hay and grain. The land, moreover, is easily cleared. At the present time nearly all grain used in this country is imported from Edmonton or Athabaska Landing, but this state of affairs bids fair to be speedily remedied, because, from experiments extending over many years, it has been amply proven that even in that northern clime, grain can be successfully produced. If the alacrity shown by the more progressive Indians in settling and clearing the newly surveyed homesteads is to be taken as any criterion, one can safely predict that in a few years, following perhaps better facilities for transportation, these fertile northern lands will form a valuable addition to the granary of the Empire.

The surface of the country at Smith Landing is mostly flat and gently rolling, and is well wooded, the prevailing species of timber being black and white poplar and

spruce, the latter attaining a diameter of about two feet. With the advent of the Government saw-mill, much building is going on, opening up new avenues of employment for the hardy pioneer.

Hay is obtained from the sloughs within the settlement and also from the islands in Slave river, from which it is transported during the winter on the ice. The quality is that of ordinary slough grass, and there is an abundance of it for all ordinary requirements of the settlers.

The water is all fresh and at present is supplied by the primitive method of dipping from Slave river, but good water can easily be obtained by sinking wells to a depth of from fifteen to twenty feet. There are no streams through the settlement, and the land is not liable to be flooded.

Below Smith Landing there are sixteen miles of rapids on Slave river, having a drop of approximately 140 feet in sixteen miles. It could be dammed and much water-power developed.

Upon the completion of my work in this vicinity, teams were hired and my outfit transported across the sixteen-mile portage to Fort Smith, over as good a road as it has ever been my pleasure to travel.

Fort Smith is beautifully situated and is high and dry, being on the level plateau, one hundred and fifty feet above Slave river. The general characteristics of the district resemble those at Smith Landing. The soil is mostly a sandy loam. The Government Experimental Farm, under the able supervision of Mr. A. J. Bell, Dominion Government agent, is leading the way in agricultural pursuits, and the results of the experiments are very satisfactory.

Fort Smith is noted as being the head of continuous navigation for fifteen hundred miles to the Arctic ocean. At present three small steamers ply from this port down the Slave and Mackenzie rivers. I am informed by Mr. Brabant, chief factor of the Hudson's Bay company for Mackenzie district, that the Company is contemplating bringing supplies into this country from the Arctic and up the Mackenzie in the near future, as a cheaper and safer method of transportation than that now employed of using scows down the Athabaska.

A few remarks at this juncture regarding the Salt river country, twelve miles northwesterly from Fort Smith, might be of interest to the Department.

The great natural salt beds of Salt river are well known. I will only mention in passing that pure salt is here as plentiful as sand on the seashore, and the supply used in this country, for all purposes, is obtained from this source. Here also are found the last great prairies, where the noble buffalo reigns supreme, protected from ruthless slaughter by the Canadian Government. But they are bound to be driven before the onward march of the Canadian farmer, for these prairies are already being claimed as the farmer's heritage. The Roman Catholic mission has, as usual, turned the first sod and now has a ranch of nearly one thousand acres, producing cattle, horses, hay and grain. The Government has here also a large Experimental Farm in a flourishing condition.

The summer weather conditions are ideal. The days are warm, the nights are cool, but frosts during June, July and August are rare. For several weeks in June and July there is no darkness, accounting of course, for the rapid plant growth. The winters, I believe, are scarcely more severe than those of the Manitoba prairies, but the season is longer.

The chief industry of the district at the present time is fur-trading. The rival companies, the Hudson's Bay company and the Northern Transportation company have posts at all settlements. Fish and game, consisting of moose, deer, caribou and water-fowl, as well as the ordinary fur-bearing animals, are plentiful.

I was occupied approximately five weeks in making the survey of Fort Smith settlement, which extends about six miles along Slave river; I believe the available surveyed homesteads will be sufficient for several years to come.

On September 25, I left Fort Smith on my return journey, crossed the portage to the landing, and through the kindness of Mr. Bell was permitted the use of the steamer *Rex* to take me up Slave river. On board this tug I left Smith Landing on September 27, and reached the Little rapids on Rocher river on the evening of the 29th. Here it was necessary to leave the steamer as it could not stem the rapids. On the following day, tracking was resorted to, and I arrived at Chipewyan on the same day.

At Chipewyan, supplies which I had cached on my way down, were taken on board, and I left there on October 1, paddling across Athabaska lake and up Athabaska river. With beautiful weather and continuous paddling the party arrived at McKay on October 10. Above this point the river flows too swiftly to paddle against, so I disposed of one canoe, putting all the baggage in the remaining one, and after two days' hard tracking reached McMurray on the 12th.

This is where the most difficult part of the journey commenced. The water was very low as the snowfall in the mountains had been light the year before. It was necessary to lengthen the tracking line to 250 feet, and even then the canoe drawing about ten inches would not float clear of the shoals and rocks. At times this necessitated wading knee-deep in the icy waters, but happily conditions improved when the Crooked rapids were passed and with the usual portage we slowly advanced up the river and arrived at House river, ten miles above the Grand rapids on October 22. Here we met with a twelve-inch fall of snow which made travelling hard and unpleasant, as it was necessary to walk along the shore and track the canoe.

Daily the weather was growing colder and ice began to drift in the river on the 29th, finally stopping the canoe on the 31st, a short distance below Calling river and about fifty miles from Athabaska Landing. At Calling river I was fortunate in obtaining pack-horses, and thence following the Government telephone line I arrived at Athabaska Landing, overland, on November 4th.

APPENDIX No. 40.

ABSTRACT OF THE REPORT OF T. H. PLUNKETT, D.L.S.

Base Line Surveys in Manitoba and Saskatchewan.

SURVEY OF THE THIRTEENTH AND FOURTEENTH BASE LINES IN THE VICINITY OF THE PRINCIPAL MERIDIAN.

I organized my party at Winnipeg, and, on February 14, 1912, the party and equipment arrived at Chemong siding on the Pas branch of the Canadian Northern railway, ready to commence the survey of the thirteenth base through ranges 32, 31, 30, 29 and 28, west of the principal meridian. A few days were spent in reaching the starting point of this base, and actual survey operations commenced on February 17.

The country traversed by this line was mainly of a swampy nature, the surface being almost entirely covered with moss, varying in depth from three inches to two feet. Numerous floating bogs were crossed, but, generally speaking, there is a solid bottom of gravelly clay or of sandy loam lying about eighteen or twenty inches below the moss. Between the moss and clay lies a layer of black muck. The floating bogs are a semi-liquid mass of decaying vegetation, extending, as a rule, in a northwesterly and southeasterly direction, and are sometimes of a considerable depth, rendering travel over this country in summer almost impossible. Notwithstanding the fact that the country has ample slopes for drainage to the water-courses, it remains inundated over large areas after the snow has disappeared in the spring. This is caused by the carpet of moss, which prevents the water from reaching the outlets provided by the rivers.

During the course of the survey a few very narrow ridges were crossed, but these are inaccessible owing to the interlying swamps and bogs, and, even aside from this, they offer, in their present condition, meagre encouragement to the settler.

There is in this country a drainage proposition which, in my opinion, cannot be solved by individual settlers, but should be undertaken with a view to draining the whole country, following a well-devised plan. To allow homesteaders to attempt to convert this into farming land from its present condition is almost sure to result in failure, and hence would be a set-back to the development of what could be made, I think, a fair farming country. Notwithstanding the fact that public attention has been so forcibly directed during the past three years to this portion of the Canadian west on account of the railroad construction, past and present, no attempt at agriculture has been made, to my knowledge, along the already operating Pas branch of the Canadian Northern railway. This fact seems to prove conclusively that something must be done towards improving the drainage before settlers will attempt to work the land.

This is, of course, a bush country, the prevailing varieties of trees being spruce and tamarack. These are of no commercial value, and are, as a rule, small. South of the base line in ranges 28 and 29, spruce suitable for ties was found, but not in large quantities.

Overflowing river, a stream about eighty feet wide, was crossed in section 31, range 29. It flows northeasterly, with a current of two to three miles per hour. The banks are low and the country for a half-mile on either side shows evidences of flooding. No available water-powers were seen.

This base line was completed to the easterly limit of range 28 on March 15, and the outfit was then moved back to the second meridian, where work was commenced at once on the same base line west of the meridian and continued to the easterly limit

of range 2. The line in range 2 began the ascent of the Pasquia hills, and, as my party was to remain in the field continuously throughout the spring and summer, it was deemed wise to abandon the survey of this base at present and to return to it when the spring break-up rendered work impossible at lower elevations.

Accordingly, a move was made to Whitehorn siding, by train, and from there by dog teams to the point of commencement of the fourteenth base line on the second meridian, a distance of about twenty miles.

Work was commenced on this base on April 1, but no sooner had we begun, than the spring break-up commenced. By April 5 the snow was practically gone, and we found ourselves surrounded by a country flooded to a depth of from one to two feet. Wading through this ice cold water soon had its effect on the personnel of my party. There arose an irresistible desire amongst the labourers to seek more congenial employment. Every remaining member of the party became an axeman, and both line and outfit reached better footing in range 28, on April 18.

From the commencement of the base in range 31 to the western limit of range 28, the country showed every evidence of being flooded, in the spring at least, this notwithstanding the fact that six water-courses were crossed in this distance. In section 33, range 31, a river forty feet wide, with banks four feet high, flows north into Waskwei river, which, in turn, was crossed in section 31, range 30. Waskwei river at this point has a width of sixty-six feet, with banks six feet high, and flows north to join Carrot river. In addition to these rivers, creeks fifteen feet wide were crossed in sections 33 and 34, range 31. Pasquia river flows through section 35, range 30. This river is about one hundred feet wide, with banks five feet high. It flows north into the Saskatchewan at Pas. We found these rivers frozen almost to the bottom and were unable to determine their currents. These, of necessity, must be slow. At high water on the Saskatchewan, Pasquia river provides a channel for conducting the surplus Saskatchewan water over the country. From this peculiarity Pas receives its name, Pas being a shortened Cree expression for a river that flows in two directions. In section 33, range 29, a stream one chain wide was crossed. This has no well-defined banks, and meanders northerly through an extensive floating muskeg to join Pasquia river.

Ranges 31, 30 and 29 are, at present, utterly unsuited for agriculture, and the country presents serious drainage difficulties. Although we did not have an opportunity to observe the rivers at high water, there are numerous evidences that they are insufficient for the country's drainage.

In range 28 the country became more rolling, with fewer disadvantages to settlement, though it, too, is far from desirable agricultural land. On all sides deep moss covers the ground, but under this there is a depth in places of over two feet of black loam; other parts were clay, carrying limestone boulders. This range has been burnt over along the Canadian Northern railway.

The line passed through a country continuously wooded. In range 31, there is a large area of tamarack swamp. In sections 31 and 32, tamarack and spruce range from six to eighteen inches in diameter, but the tamarack is nearly all dead. Throughout range 31, considerable areas of this swamp were encountered in every section. These patches of timber alternate with low wet places, generally covered with dense willow brush. In ranges 30 and 29, the heavy timber disappears and gives place to a dense growth of small spruce and tamarack on the comparatively dry ground, while on the bogs there is a scattered growth of stunted trees of the same varieties. Throughout range 28 the country is wooded with a dense growth of small spruce, suitable only for cordwood. In range 27 the land appears to drop again.

Having reached the easterly limit of range 28 on April 23, it was decided to return to Chemong and continue the thirteenth base west of the second meridian. Dogs, which had been our means of transport during the winter, were now dispensed with and pack horses substituted for work on the Pasquia hills, where we were sure of solid ground.

Work there was commenced on April 26. In range 2 we reached the base of the Pasquia hills. Regarding the land in ranges 1 and 2, there is no good reason why this should not be, in the future, a good farming country. At present, however, these ranges are covered with excellent merchantable timber, consisting of spruce and tamarack, and lumbering operations are now flourishing. There is a saw-mill in operation one mile south of Chemong siding, and lumbering is in progress all along the railway from Hudson Bay Junction to mileage 40.

In ranges 3 and 4, the line crossed the Pasquia hills. The summit of these hills is 1,348 feet above the level of the Canadian Northern railway track at Chemong siding. These hills are cut up by deep ravines, through which flow streams of good water. The land is mostly too rough for farming, and no attempt to cultivate it will likely be made for some time. An excellent view of the surrounding country is to be had from the summit of the hills. The side slopes are wooded with spruce, birch and poplar, with usually a dense undergrowth of brush. The summit is covered with brulé and considerable swamp, with patches of dense small spruce and tamarack of no commercial value.

The following remarks regarding game, minerals and climate will apply to all the country mentioned above. Game, including moose, caribou and deer, is very plentiful; east of the second meridian caribou are especially numerous. The moose appear to live in the Pasquia hills in summer, and are not often seen on the lower land until the snow in winter drives them out of the hills. Mink were seen on the Overflowing, Waskwei and Pasquia rivers, and traces of lynx were in evidence, though they are not plentiful. Muskrats do not appear to flourish here. Bears are very numerous in the Pasquia hills, and rabbits and grouse abound. Timber wolves are fairly plentiful.

A salt spring, the water of which was decidedly saline, was found flowing freely in March in range 28 on the thirteenth base east of the second meridian. Salt springs, I am told, are of common occurrence in this country, but, with the exception of these, no traces of minerals were found.

Except for a large meadow south of the thirteenth base line in range 2, west of the second meridian, there is little likelihood that horse feed of anything approaching first-class quality is to be found. No meadows were seen on the Pasquia hills, and the country as a whole seems particularly devoid of grasses.

The winter of 1912 was considered a severe one throughout the West. During February our thermometer registered as low as 38 below zero, and snow to a depth of two or two and a half feet covered the ground, but the snowfall in February and March was very light. Bright, cold days succeeded one another until April 1, when there was a decided rise in temperature and spring commenced at once. Although living in tents we did not feel the cold severe, and no time was lost to the survey work during February and March on account of stormy or excessively cold weather. Night frosts continued throughout April and May, and the last frost noticed occurred on the night of June 5. A severe snow-storm commenced on April 27, and snow to a depth of eight inches fell in range 2 on the thirteenth base west of the second meridian. The temperature then began to rise and rain continued every day until May 7. The country was flooded on all sides, and severe washouts occurred on the railway. There was no sign of spring growth on the Pasquia hills until May 28, but when work in this locality was brought to a close on June 14, the weather was decidedly hot.

SURVEY OF THE TENTH BASE LINE WEST OF THE PRINCIPAL MERIDIAN.

The party moved to Winnipegosis on June 15, 1912, and after a short delay, owing to a storm on the lake, we sailed from there across lake Winnipegosis, and up Waterhen river to Waterhen lake.

The boats were first taken north on Waterhen lake, to where it was expected that the tenth base would strike the lake shore. Our provisions were unloaded there and five men were left with instructions to move supplies east as far as possible, as soon as the pack horses which had been sent overland around the lakes arrived.

With the remainder of the party and sufficient supplies, we then sailed south to the intersection of the ninth base line with the more easterly of the two Waterhen rivers. These rivers, one of which flows north from lake Winnipegosis to Waterhen lake and the other south from Waterhen lake to lake Manitoba, are almost parallel, and only a few miles apart.

Our horses arrived on June 21, and twelve were sent north at once to move our provisions east, while twelve were retained for transport along the block outline leading up to the tenth base. Work was commenced on June 22 and continued without serious delay until the base line was completed on November 5.

We found on starting our work that Mr. P. E. Palmer, D.L.S., had, as part of his contract, already surveyed the eastern boundary of township 33, range 15. This work was retraced according to instructions and new surveys commenced at the northeast corner of section 36, township 33, range 15, west of the principal meridian. The work then proceeded without delay until the northeast corner of township 36, range 15, was reached on July 5.

There, I was disappointed to find that efforts to move our provisions east, along the supposed course of the tenth base had not been successful. Floating bogs on which it was impossible to take the horses seemed to stretch in all directions.

As long as our work had led us in a northerly direction, the bogs, which are characteristic of this whole country, had not hindered our progress, because running, as they did, almost due north and south, good trails could be found on open ground along their edges. When our work turned east and west, however, it was quite a different proposition to transport supplies. Merely extending the survey was a comparatively easy task.

Before setting to work to cross these bogs with our supplies, I decided to make an exploration easterly to find what likelihood there was of being able to go forward with the base, provided the bogs we were in could be crossed. With Mr. C. J. Harper, one of my assistants, I travelled about fifteen miles east, and found the country steadily improving from a transportation standpoint.

The only good farming land seen during the summer is situated at the commencement of our work. Portions of townships 33, 34, 35 and 36, range 15, offer a few splendid locations for settlers. The more easterly of the Waterhen rivers seems to drain this range fairly well and offers an excellent means of drainage for the parts still wet. The wild grasses in this locality were of nutritious quality, and the soil generally placed this range in a class by itself from an agricultural standpoint. East of the easterly limits of range 15, in the townships mentioned above, floating bogs occupied large areas and for the more southerly of these I am doubtful if there are drainage facilities to lake Manitoba.

The country along the tenth base line as far east as range 10, is a regular succession of floating bogs, in which there was considerable open water and ridges.

The ridges in range 14 are generally suited to agriculture, but in summer they are practically inaccessible. The soil on these ridges is of fair quality, but after this range is passed the ridges are very stony. Our levels show a decided western slope to the land and the bogs no doubt could be drained. It has been the experience of farmers, who have drained similar bogs, that they make excellent farming land. The depth of these varies greatly; in some of them midway between the bordering ridges I found a solid clay, carrying boulders at four feet deep, while in others a pole sixteen feet long could be pushed down easily and at this depth no bottom was reached. The notes of our survey give no idea of the area occupied by these bogs, as they lie almost north and south. I would roughly estimate that they constitute from 60 to 75 per cent of the whole country.

Photo by J. R. Akins D.L.S.
Camp in Tp. 96, R. 17, west of the Fifth Meridian.

Photo by J. S. Galletly, D.L.S.
Pack Trail in Tp. 109, R. 15, west of the Fifth Meridian.

The ridges in range 14 were wooded with merchantable spruce, poplar and birch. In ranges 13, 12, 11 and 10 the predominating timber is jackpine, spruce and tamarack of no commercial value. I did not see even tie timber from range 13 to Warpath river in range 7. After range 10 was passed the jackpine entirely disappeared, so also did the ridges, and the country became almost impassable.

In ranges 9, 8, 7 and 6 moss covers the ground to a depth ranging from two to four feet. The bogs, unlike those in the previous ranges which are generally open, are wooded with stunted tamarack.

On all sides small lakes were seen, and a slight pressure on the moss will show water at the surface. It was very difficult to find sufficient solid ground in range 8 on which to camp. The whole range, as well as ranges 9 and 7, had to be corduroyed in order to get our horses to the banks of Warpath river, in range 7. Ranges 9 and 8 are wooded with spruce and tamarack only, and these too small to be of value.

On reaching Warpath river on September 17, our horses were turned loose to feed along the banks. This grass was the only horse feed of anything like good quality we had been able to get since leaving range 14. After feeding on this grass for three weeks three horses died, and little improvement could be noticed in the condition of our remaining horses on November 4 when we came out.

Throughout ranges 7, 6 and 5 man-packing was resorted to, and the line carried through to lake Winnipeg.

Between the river in range 7 and lake Winnipeg there lies a large tamarack swamp, streaked with floating bog. The tamarack are large, and would be suitable for ties.

After the completion of the base to lake Winnipeg, a return was made to Warpath river, where my cook outfit had been stationed while supplying provisions for the work in the last two ranges. It was decided to take advantage of the means of transportation afforded by this river to run the block outlines between the ninth and tenth bases. The camp outfit was moved in boats up the river and camps established on the bank. This necessitated rather long walks to the work sometimes but the condition of our horses rendered their further use impossible.

The survey of the easterly outlines of townships 36 and 35, in range 8, disclosed no better land for farming. Swamp, bog and moss were continuous, and the spruce and tamarack back from the river bank still continued small and of no commercial value.

At the ninth correction line the bulk of the camp was left and man-packing again used to run the east outline of township 34, range 8, north. This six miles followed a dry, jackpine ridge, the trees ranging from six to eighteen inches in diameter and growing thickly. About two miles west of this line we found about two square miles of excellent spruce and tamarack. This lies approximately in sections 10, 11, 14 and 15 of township 34, range 8. The soil on the ridge is light and sandy, but west of that, in the spruce, it is good.

One of the striking features of this whole country is the absence of creeks and rivers. Not until we reached Warpath river, in range 7, did we cross a river or even a creek, but on one or two bogs I noticed that water was flowing quite rapidly through the grass over the whole surface of the bog. Often, on going a second time over our horse trails in the moss, we found the water flowing freely down the trail. When Warpath river was reached, we were surprised to find that although this river, sixty feet wide, flowed with a current of from three to three and one-half miles per hour, it did not seem to have any drainage effects on the country through which it passes, the bogs extending almost to the river. No doubt the depth of moss prevents the water from gaining an outlet.

We had an opportunity, during the summer, to see the enemy of the tamarack trees hard at work. Thousands of these short green worms were to be found feeding on the needles of the tamarack and they entirely stripped the trees of their foliage.

One could not walk among these trees without being covered with the little grubs. No tamarack, however isolated, seemed to be escaping this scourge, and what is more peculiar still, no other variety of tree was affected.

Regarding game, I may say moose and caribou are very plentiful, these animals being seen almost daily. Traces of lynx were fairly plentiful, and mink, otter and muskrat were numerous on Warpath river, but only a few traces of bears were seen. Rabbits and grouse are particularly plentiful. Jackfish were abundant in Warpath river.

During the latter part of June and the first part of July, the heat was intense and no summer frosts were noticed. The lakes were open until November 5. The first frost occurred on September 14 and 15, when thin ice formed on the standing water in the swamps.

Notwithstanding the large gypsum deposits north of the ninth base, no trace of this or any other material was seen on our work.

On November 5 we commenced our journey to Gypsumville. It had been thought that we could take our outfit up Warpath river to Gypsum lake and thence to Gypsumville, as maps of this country show the river flowing out of Gypsum lake. The main Warpath river does not, however, rise in Gypsum lake, but in Pine lake, some distance west and north of Gypsum lake. Moreover, there is no continuous waterway from Gypsum lake to Warpath river, and we were forced to take our camp across the portage, which is a large floating bog, to Dauphin river and up the Dauphin to lake St. Martin. This lake we found frozen over at the source of the Dauphin and we had to man-pack our belongings to where a yoke of oxen could reach them and take them to Lake St. Martin Indian reserve. The country was in a very wet condition after the unusually wet summer and it was November 18 before the camp equipments reached Gypsumville.

SURVEY OF THE ELEVENTH AND TWELFTH BASE LINES WEST OF THE PRINCIPAL MERIDIAN.

We left Chemong on December 16, 1912, for Fishtown siding, near Novra station on the Canadian Northern railway. A few days were required to open up the old sleigh road, which leads easterly from Fishtown to the Swan Lake Indian reserve. Supplies and equipment were soon placed in range 24 and survey work commenced at the quarter post on the north boundary of section 36, township 40, range 25, west of the principal meridian, on December 28.

In range 24, some very good farming land was crossed. This land is wooded fairly heavily in section 31 and 32. Wood river, a stream 100 feet wide, with well defind banks and flowing north through the Swan Lake Indian reserve to Swan lake, was crossed in section 32. Section 33 and fractional section 34 are low-lying meadow land. The Indians on Swan Lake reserve report that previous to the summer of 1912, they were able to cut hay on all this land but during this exceptionally wet season they were unable to harvest hay excepting on land near Swan lake.

In section 34, Swan lake was reached. This lake is very shallow, and freezes almost to the bottom. Fishing is carried on by the Indians on Swan river, the mouth of which was crossed in section 31, range 23. No fishing appears to be done on the lake, and only jackfish and pickerel are caught in the river no whitefish being found there.

Having crossed the lake we saw some excellent farming land in sections 31, 32, 33 and 34 in range 22. This belt of good land extends along almost the entire easterly shore of Swan lake. This country, of course, is heavily wooded but the soil is of excellent quality and in section 32 the land lies fifty feet above Swan lake. In section 35 the land drops considerably and a large area of swampy country covered with deep moss and wooded for the most part with scrub, spruce and tamarack, extends far north and south of the base. The description of the base line through section 36, range 22, and sections 31, 32, 33 and 34 of range 21, cannot be taken as a fair indication of the nature of the country in general. The line there approaches Pelican lake, and running for some distance through country immediately south of the lake, passes through land heavily timbered with excellent spruce, poplar, birch and tamarack, and presents some good locations for settlers. Large meadows extend south from Pelican lake

through sections 33 and 34, range 21. There is, I think, no doubt that a considerable portion of these could be cropped.

Creeks were crossed in sections 32 and 33, range 21, flowing north to Pelican lake, but the water in these was decidedly saline.

My ranger reported that north and south of the base in range 21, the country from an agricultural standpoint is far inferior to that described in the field notes of the survey. North of the base, small spruce and tamarack are found in all directions, with an almost continuous scattering of small jackpine. Open grassy stretches were occasionally met, which, from his description, I expect were floating bogs. South of the base the country was more promising, larger areas of spruce and poplar being found.

In section 34 the west shore of Pelican lake was reached. This lake is a much larger body of water than the maps of this district indicate. It measured over five miles in width, where the base crossed it and extends southeast to within two miles of lake Winnipegosis. It appears to be as large as Swan lake.

The country between Pelican lake, in range 20, and lake Winnipegosis, in range 18, is, for the most part, swampy, though apparently not nearly so wet as the country along the Pas branch of the Canadian Northern railway. In range 19, the land becomes more rolling and poplar ridges were crossed in section 35. I think this country might be developed into fair agricultural land. Lying under the moss and muck is a sandy clay, carrying limestone boulders. This limestone lies within eight inches of the surface in section 36, township 40, range 19.

The country is principally covered with spruce, tamarack and occasional jackpine. Brulé covers the surface in range 19. A considerable spruce forest once flourished in this range, but fire has completely destroyed it.

With range 18, the country again becomes a swamp, wooded as before with scrub spruce and tamarack, until the usual narrow strip of high land bordering lake Winnipegosis is reached in section 32.

With the exception of Birch island, no more land was crossed on this base. This island, lying in sections 35 and 36 of range 18, and sections 31, 32 and 33 of range 17, contains a limited amount of good agricultural land. It is wooded with small poplar, birch, spruce and tamarack and for some distance in the centre of the island, the land becomes swampy, but this could be easily drained.

Having crossed lake Winnipegosis, the base was carried to the northeast corner of section 36 in range 16. East of lake Winnipegosis, the land along the base was very swampy, small lakes being numerous. High land is found south at a distance of about five miles but north the usual swamp, characteristic of this country, stretches far and wide.

By February 21, 1913, the work was completed on the eleventh base and the party started at once for the twelfth base line in township 44, range 25, west of the principal meridian.

The return was made along our own trail on the eleventh base, as far as Swan lake in range 23. The party was then taken north on Swan lake and Shoal river to the Armstrong Trading Company's post on Dawson bay. There advantage was taken of the winter road between Pelican Rapids post-office and Mafeking as far as Steeprock stopping place where we found ourselves, on March 3, only a few miles south of our point of commencement on the twelfth base line.

Acting on your instructions, a retracement survey was made on the north boundary of township 44, range 25, and new surveys commenced on the twelfth base in range 24, on March 10.

Throughout ranges 25 and 24 our surveys traversed a rolling country which, as we approached the shore of Dawson bay in section 31, range 24, was fairly heavily wooded. In the valleys the country is generally of a swampy nature, but, with proper drainage, it could no doubt be utilized for agriculture. The higher land is wooded with spruce, tamarack, poplar, birch and balsam. Generally speaking, the timber is

as yet too small to be of value for lumber, but some trees close to the lake, in range 24, measured as large as twenty-four inches in diameter. The soil in range 24 consists of clay, carrying limestone boulders, and outcrops of limestone rock are frequent all along the lake shore.

The easterly shore of Dawson bay was reached in section 32, range 22, the base having crossed narrow points in sections 35 and 36 of range 23, and section 31 of range 22. These points form part of Indian reserve No. 65 B.

Surrounding Dawson bay south of the base in ranges 24 and 23 there is a strip of land from one to two miles in width, wooded very heavily in places with spruce, tamarack, birch and poplar up to twenty-four inches in diameter. This, when cleared, would afford some excellent locations for settlers. In fact, from our explorations through the whole country adjacent to the eleventh and twelfth base lines, it may be fairly well described by saying that contiguous to the lakes there is always to be found a belt of high land which when cleared would make good farming land. Back from the lakes, one, two or at most three miles, the country either remains a mossy swamp or, what is worse, a floating mass of decaying vegetation.

In ranges 22 and 21, the base crossed the point of land separating Dawson and Pelican bays. Here again we found, on either side of the point, fairly high gently-rolling land, well wooded with spruce, birch, poplar and tamarack and adapted for agriculture, while the intermediate land still remains a mossy swamp wooded with stunted spruce and tamarack.

The only other land touched by the base, as far as we surveyed it, lies on the narrow point separating Pelican bay from the main Winnipegosis lake. This land lies in sections 33, 34, 35 and 36 of range 20, and sections 31 and 32 of range 19.

Owing to the narrowness of this point, practically all the country traversed by the base line and north of it is fit for agriculture, but south, where the point is wider, the muskeg is found, as usual.

The soil on the high ground consists of clay loam with limestone gravel or boulders. The swamp land is covered with moss, under which lies a layer of about one to two feet of black muck. The subsoil is clay carrying limestone boulders. Outcrops of stratified limestone are frequent on the lake shore and on points running into the lake.

The survey of this base was completed to the northeast corner of section 33 in range 16, on April 3, and the return journey to Mafeking station was commenced at once. We returned by our own trail along the base line as far as Whiskey Jack point. There we reached the winter road which leads to Mafeking via Pelican Rapids post-office. The party reached the railway on April 8.

During the winter of 1912 and 1913, some intensely cold weather was experienced, especially from January 4 to February 14, the thermometer registering as low as 60 below zero on January 19, 20 and 21. Seldom during this period did the temperature rise above 20 below zero. With the exception of this cold spell, however, the weather was very favourable for survey work. In fact only three days were lost during the entire winter owing to the excessive cold. The snowfall was not heavy, there being at no time more than two feet of snow on the level. Snowshoes were seldom used. The fall of 1912 was exceptionally fine, no cold weather being experienced until late in December. By April 8 the snow had almost entirely disappeared, and spring opened at once.

Winter fishing was carried on by the Indians and white settlers on lake Winnipegosis during the entire winter. Whitefish, pickerel and jackfish are caught there in large numbers. Fishing and trapping afford ample winter work for settlers in this locality.

Game, including moose and deer, is very plentiful. The moose live in the Porcupine mountain in summer. In winter they are to be seen daily throughout the country traversed by the eleventh and twelfth base lines. Rabbits and grouse are

numerous and during the past winter many bevies of the white grouse or ptarmigan were seen. Muskrats, mink, lynx and otter are also fairly plentiful throughout this country. Timber wolves are rarely seen now, but large numbers of brush wolves are still to be found on the lakes in winter feeding on the piles of fish offal left by the fishermen. These animals are said by trappers to be slightly larger than the prairie wolves, but they do not travel in packs and appear very cowardly.

On the completion of this work the party was paid off at Mafeking on April 10.

APPENDIX No. 41.

ABSTRACT OF THE REPORT OF R. C. PURSER, D.L.S.

MISCELLANEOUS SURVEYS IN SOUTHERN SASKATCHEWAN AND ALBERTA.

The work on which I was engaged during the season of 1912 consisted of small scattered surveys in the provinces of Saskatchewan and Alberta.

My first important survey was the extension of section lines on the dry bed of Goose lake in township 32, range 10, west of the third meridian. This work was commenced by Mr. W. A. Scott, D.L.S., in December, 1911, but cold weather prevented its completion at that time. The banks of this lake are from five to twenty feet high and the bottom is a great and almost level stretch of clay soil. With the breaking up of the surrounding prairie, the water has all disappeared, leaving a perfectly dry expanse that is gradually becoming covered with vegetation which is growing out from the old banks towards the centre. No doubt in time the whole flat will be one large stretch of prairie, hay and farming land.

In township 39, range 1, west of the third meridian, two sets of duplicate monuments along the south boundary were noted. No information could be obtained from the residents as to which were the correct monuments and no explanation could be made as to the cause of their existence. Fourteen miles of line were retraced in an endeavour to determine the correct line. All appeared to be in the same state of preservation and no pair of monuments corresponded with the measurements given on the plan. The correction of these duplicate monuments thus resolved itself into the selection of those monuments which would give the most equitable portion to all the quarter sections involved. These were selected and renewed and the others were destroyed.

In township 39, range 13, west of the third meridian, the monuments had been reported lost, and an examination was made to determine if the survey was necessary. It was found that a resurvey was urgently required. This district is reached by good trails from either Maymont or Radisson on the Canadian Northern railway and then by a ferry across Saskatchewan river. The township, being in the midst of the Eagle hills, is rather rough and is, for the most part, covered with a heavy growth of poplar and balm of Gilead. A luxuriant growth of pea-vine and wild flowers cover the best portions to a height of three or four feet. A large number of the original monuments in this township could not be found, and this fact has seriously hindered the taking up of the land by homesteaders. An attempt had been made by some of them to lay off their quarter sections by compass lines. The few settlers at present in this township are obtaining good crops. Scarcely any trails except winter roads lead into the dense growth in the central portion of the township. To drive farther west one must make a detour either to the north or south over circuitous trails.

A traverse of part of the east bank of South Saskatchewan river in township 33, range 6, west of the third meridian, proved very arduous work for a travelling party of two persons. Commencing at the intersection of the north boundary of section 24 with the river bank, I traversed the shore northward to the north boundary of the township. This was necessarily through thick bluffs of poplar and alder along the top of the river bank, it being impossible to use the beach on account of its narrow and winding nature. Formerly the main body of the river flowed along the west shore, but recently changes have occured and now the current runs swiftly along the east bank where it has already, by a gradual erosion of the sandy soil, worn away several acres from some quarter sections. Two islands were surveyed; the larger one, con-

taining roughly about three hundred and fifty acres in township 33, range 6, west of the third meridian, has virtually become part of the mainland due, probably, to changes in the river level since the original survey. A channel less than one chain wide separated the island from the river bank. At present this old channel still exists but it requires a rise of four feet from the average level of the river to send any water through it. This island is of little value for agricultural purposes at present as the soil is light and the surface is thickly wooded. Evidences are also present showing that within recent years the whole island has been inundated by the waters of the river.

In township 49, range 6, west of the third meridian, several lakes were traversed which had been missed by the original subdivider; one of these was about four hundred and twenty acres in extent and was reported to be over one hundred feet in depth.

Many other small surveys besides those above noted were made.

The progress of the season's work was hampered somewhat by the very wet weather that prevailed during the summer months.

APPENDIX No. 42.

ABSTRACT OF THE REPORT OF C. RINFRET, D.L.S.

MISCELLANEOUS RESURVEYS IN SOUTHERN SASKATCHEWAN.

I organized my party at Moosejaw and, on June 5, 1912, left for my first work which consisted of investigating duplicate monuments in five townships southeast of Moosejaw. A second subdivision of these townships were made in 1883 and the then existing monuments were not all destroyed. All the land in these townships was taken up long ago, and most of it is now under cultivation.

The next work, which was reached on June 29, consisted in surveying the dried-up portion of the bed of Johnston lake, southwest of Moosejaw This portion is an alkaline flat yielding abundant hay of second-class quality, and covers an area of about six square miles. Township 14, range 29, on the north side of the lake has sandy loam soil, and although very rolling in the north it is rapidly being taken up by homesteaders. The north third seems best adapted for ranching.

Having completed this work, we proceeded by trail to some townships northeast of Maple Creek which were to be resurveyed, arriving there on August 22.

Townships 14, ranges 23 and 24, west of the third meridian, consist for the most part of sand hills covered with shrub and are at best only suitable for ranching, hay being found in places and good water being easily obtained.

A strip of good loam soil, fairly level and about four miles wide covers the northern part of townships 15, ranges 23 and 24, beginning near Bigstick lake and stretching eastward, but the south third consists of sand hills and is useless. In township 15, range 23, oats and wheat grow splendidly, and the township is being well settled. Most of township 15, range 24, is leased to ranchers, although there are a few good homesteads still available.

In this district the settlers complain of the lack of herd law, as cattle and horses are allowed to roam at will, damaging the crops of those who have not the means of fencing up their land.

The north third of township 13, range 25 has a good soil but it is very rolling and would be best suited for ranching.

The whole of township 15, range 26, has good soil and is fairly level. It is now all taken up and partly cultivated by numerous German settlers. Two years ago not a shack could be seen for miles around.

Having completed the survey of this township I disbanded my party on October 18, after which, with my assistant, I proceeded to make a few miscellaneous surveys.

I corrected wrongly-placed monuments in townships 14, ranges 1 and 10, and also in township 32 range 26, all west of the third meridian. This necessitated driving, and travelling by rail.

My next work was to survey those parts of the townships bordering the Quill lakes which had dried up since the original subdivision. These lakes had not dried up to any noticeable extent except in townships 32, ranges 17 and 18, and township 33, range 18, west of the third meridian, where a few square miles required subdivision. I also surveyed a few lines in township 34, range 16.

The land recently dried up consists mostly of an alkaline flat, swampy in places, and not much good for farming. It yields plenty of fairly good hay, but only one crop every other year.

Some changes were also found in township 34, range 14, and township 35, range 17. In the latter township the lake is larger than on the original plan, but as there were no farmers living in that vicinity we were unable to get board, and the survey could not be conveniently done at that time. Therefore, after completing the inspection of all the other townships bordering the lakes, I closed operations for the season on December 12.

APPENDIX No. 43.

ABSTRACT OF THE REPORT OF A. SAINT CYR, D.L.S.

SURVEY OF PART OF THE EIGHTEENTH BASE LINE WEST OF THE THIRD MERIDIAN.

On February 21, 1912, with four loaded teams of my own and four others hired from Mr. W. C. McKay, we left Big River, where my supplies and outfit had been shipped by rail, for Doré lake. On this trip we took the new Isle à la Crosse winter road and, after crossing the portage between the south end of Cowan lake and lac DeLaronde, we travelled the whole length of the last-mentioned lake. We then crossed another portage to Sled lake, where there is a small settlement near its north shore. Here travellers are always pretty sure to find lodgings and also feed and stabling for their horses at the home of an enterprising fur trader who took up land ten years ago and has since cultivated part of it, raising oats, barley and vegetables.

Good hay in quantities can also be procured from meadows not very far distant from the settlement, and this should be an inducement to any rancher looking for a suitable location.

From Sled lake, the winter road runs through a flat and sparsely wooded country which extends to a deep but narrow bay at the south shore of Doré lake; this bay opens out in the lake five miles north of the place where the overland route ends, and at the north extremity of the high headland which closes this bay to the west, is now located one of the company's fishing stations, which we reached on the night of February 24.

On February 28, we arrived at a point on the northeasterly shore of Doré lake where it was decided to build a cache. The hired freighters left us here and returned to the fishing station.

I discovered an old road leading to lac La Plonge, and while my men were at work building the cache I blazed this road anew for several miles, so that the packers would have no trouble following it when going to the cache for supplies later on. A rough compass survey of the west half of Doré lake was also made from this camp.

On March 4, I joined my men who had finished the cache and the next day we began our return journey, arriving at Big River four days later. On March 9, I sent my teams by the overland route to Montreal lake, while I returned by train to Prince Albert.

The following days I spent in preparations for the trip to Montreal lake. Freighters had been so difficult to get that several loads of my supplies which the Hudson's Bay Company had agreed to forward for me were still in their warehouse at Goschen.

On March 27, my party proceeded to Montreal lake, while I remained in Prince Albert, expecting daily to get my large transit which had been sent to England for repairs.

On March 30, no word having yet reached me of the early delivery of this instrument, I made arrangements to have it forwarded to me as soon as it arrived, and proceeded north by way of Montreal road. On April 2, I caught up to my party which had just arrived at the north end of Montreal lake.

Five miles west of the lake shore, our road crossed Weyakwin river, over which it was necessary to throw a bridge one hundred feet long, as the ice had already been broken by the force of the current. The numerous large boulders which obstruct this part of the river helped materially to support and hold securely in place the bridge timbers which otherwise could not have stood the pressure of the drifting ice and of the rising waters of this turbulent stream.

From Weyakwin river the road was opened four and one-half miles farther west to the shore of Weyakwin lake, over which we had to travel on ice six miles north before coming to a stream, the general course of which is northwest. The ice here was showing signs of giving way in many places so that after the freighters had dumped their loads on the banks of the river they refused to help us any farther, and I had to pay them off.

After their departure my teamsters made repeated trips between the river and the cache which some of my men were building, while others were continuing the sled road northwards to our next camping ground.

On April 13, we began the survey of the third meridian at the northeast corner of township 64.

Proceeding north of the seventeenth base line our surveys were at first carried through a hilly section of burnt country where large areas covered over with decaying fallen timber intervene with woodlands; but the trees, such as the banksian pine, spruce, poplar and birch are too small to be of any commercial value. Much brushy land which could be easily cleared was also noticed; the soil is clay loam, but it is inclined to be stony; the land is less so in the north half of township 65 where the soil consists of sandy loam.

In section 25, the meridian intersects a valley bordered on its north side by a wide strip of timber, where the trees measure up to ten inches in diameter. The general direction of this valley is northeast and its bottom lands include a few small hay meadows drained by a stream rising in tamarack swamps which extend far west of the meridian.

The slopes of the hills south of this valley and some of the wide ravines that lead to its bottom are generally denuded of timber or brush, and I noted that where the snow had melted away the hillsides were covered with dry grasses and pea-vine. It is therefore possible that during the summer months this section would afford fair pasturage for a few head of cattle. Eastward these hills slope down to Two Forks river, whose valley runs parallel to that of Montreal river.

In township 66 the surface is more regular. From the east outline the land rises gradually to a low divide, located three miles farther west, and beyond which all the streams flow north. This tract of country is very stony and wooded with banksian pine from four to ten inches and spruce four to six inches while on the top of the hills which rise west of it, poplar six to ten inches in diameter grow. The low lands which surround these hills are strewn with deadfall which makes travel very arduous. In this vicinity there is a lake and several large swamps. South of these the surface is light and rolling and covered with second growth timber. Northwards is a range of high hills close on to the north boundary of this township.

West of the divide, several deep creeks intersect the meridian. They are the headwaters of Twoforks river. Owing to the season, when our surveys were made, each of these streams crossed by our road was overflowing its banks, consequently we had to build bridges over them. To expedite this work we often utilized the beaver dams as a support for the timbers, when suitable logs were scarce or would have had to be hauled from too great a distance. For crossing the widest streams large rafts, strongly bolted, were used.

The streams were not by any means the only daily obstacles to our progress, for mile after mile of boggy ground, too soft to bear the weight of the loaded pack ponies, had to be corduroyed or brushed. Unlike the bridges, these brushed roads required constant repairs till the whole camp outfit and supplies, which amounted to several tons, had been carried over them.

These muskegs and swampy lands extend to the correction line. Then comes six miles of undulating country with drier, although very stony land, drained by the river which now turns to a northwesterly course and crosses the meridian in section 25, township 67. At intervals in the valley of Twoforks river, the timber cruiser reports having seen bluffs of spruce trees averaging twenty inches in diameter.

Starting from the corner of section 12, we travelled west through pine woods on the north side of the valley, varying from a quarter to half a mile in width. On its bottom grow dense willows and alders amongst which meanders a stream flowing east. The south side of the valley is also wooded, but the land is more broken by ridges. At one mile and a half from the meridian I came to a rapid; here the valley is only a few chains wide and the pine forest reaches almost to the creek. The trees are of a good growth. Above the rapids another valley from the south meets the one I was following, and through it flows probably the same stream I had crossed farther south in a previous exploration. Beyond the junction of these streams the pine ridges to the north gradually descend to the level of a low tract of land. The main stream now turns toward the southwest, and soon divides into several small branches. After travelling west for several hours through a wet and mossy section, with tamarack and spruce from six to eighteen inches, I returned to the line by way of section 1, where I crossed a ten-acre patch of spruce from six to twelve inches and balsam six to ten inches in diameter.

One mile north of Twoforks river the country is also low, but as we enter township 68 from the south the ground rises again and banksian pine up to ten inches is the most common timber. The surface becomes more even from there on to section twenty-four but the ordinary features of stony land and scrubby timber recur. Half a mile west of the east boundary of section 12, township 68, is a hay meadow covering about two hundred acres. In section 13 the line crosses another stream flowing northwest, and with some wild hay growing along its banks. Beyond, are large bogs separated by narrow strips of higher ground; these spread to the eighteenth base line. In these grow spruce, tamarack and birch of inferior quality

North of the base line, the explorer reports the same conditions to prevail as far as a creek, the outlet of a large lake located at three miles east of the township corner. Beyond the creek the land is better drained and supports a good growth of pine and spruce.

From section 25, township 68, we cut a trail to Montreal rapids, a distance of nearly eight miles. This road was needed for bringing to camp our mail and supplies from Montreal lake.

From the right bank of Montreal river the trail was continued to Montreal portage a further distance of one mile and a half.; by following this portage two miles and a half, we arrived at the head of the rapids. On the point formed by an elbow of Montreal river at the rapids, is a strip of spruce of good quality and size and suitable for lumber. Poplar up to eight inches is also found in patches surrounded by fire-killed timber. Where our trail strikes the rapids, Montreal river is seventy-five yards wide, its banks at this point being very low.

East from the corner of township 68, there is a low section of country supporting a poor growth of spruce and tamarack. High land is found only as we approach a lake nearly five miles long and surrounded by poplar and pine woods where the timber runs up to ten inches in diameter.

After crossing two small brooks which enter the south end of this lake, swamps intersected by a few low ridges are again met; they spread east to the river banks at Montreal rapids.

Explorations conducted farther south, across township 67, ranges 26 and 27, west of the second meridian, showed that the country there was very boggy and that the only dry land consisted in a strip about two miles wide along the left bank of Montreal river. The soil is a clay loam, apparently free from stones; poplar, pine and birch are the trees which grow in this vicinity. Throughout the country adjacent to the third meridian there is practically no grazing land except along the edges of a few streams, where scanty grass of the coarsest variety grows on land so quaky or imperfectly drained that horses did not dare to venture on it. The cause of this excess of water is due partly to the dams which the beavers have built at short intervals along the streams.

EIGHTEENTH BASE LINE.

The north boundary of township 68, range 1, runs through continuous spruce or tamarack swamps and open marshes lying along the foot of a range of hills north of Twoforks river, which flows in a northwesterly direction across the township.

These swamps extend as far as the river in section 25, township 68, range 2. Here its banks are twelve feet high and fringed with willows, back of which is a strip of large spruce trees measuring up to thirty-six inches.

In section 32 another important stream also intersects the base line, and meets Twoforks river three miles farther on. Between these rivers the land is almost level, and better drained. It is stony and covered with scrub; the soil is light. As the open land adjoining this stream was the only place where grass grew, the horses had to be held in this vicinity till we had found new pastures farther west. All our stores were also kept there for a considerable period, small quantities only being brought to the main camp as they were required.

One of our ponies mysteriously disappeared from the camp, and although a diligent search was made for him during several days, no trace of his whereabouts could ever be found.

The surface of township 68, range 3, is broken, but more so in the south half of township 69 where rises a succession of sandy hills almost denuded of vegetation. North of these is a wide depression, with a large lake discharging by an outlet a mile and a half long and seventy yards wide into Twoforks river. Along its north shore the land is level and sparsely timbered for two miles, when the ground rises gradually to wooded hills in the centre of township 70. South of the base line, the country is rolling and dotted with numerous lakes of varying sizes. The land is generally well wooded, although the timber is not very large. The soil consists of clay loam, eight inches deep; the subsoil is sand.

In range 4 we came to the valley of Smoothstone river, the outlet of Smoothstone lake which lies twelve miles south of the base line, and is one of the largest bodies of water in this district. This river first crosses the line in section 31, thence its course is nearly east for three miles, when it divides into several channels, with hardly any perceptible current. The principal one turns south across the line in section 31 and soon after discharges into a lake which covers nearly all of section 34.

Up to the place where the river divides, its valley is well defined by high hills which extend southwesterly along its course to the rapids where they slope down to benches fifty feet high. Farther south these benches merge with the level country along the north shores of Smoothstone lake. The navigation of this stream, which is frequented by the natives from Snake lake, is feasible by canoes for a distance of four miles south of the line where the rapids begin. They are reported to extend without interruption to the place where the river flows out of the lake.

In the other direction, as far as the large lake that covers a large area of townships 69 ranges 3 and 4 there are no rapids; in the narrowest stretches of river the channel is quite deep and the current slack. Along this route, Smoothstone river often expands into lakes with shallow bays, the favourite haunts of ducks, which were in great numbers at the time of our exploration.

On July 6, I left my camp on Smoothstone river, near the corner of township 68, range 5, to explore the country between the base line and Smoothstone lake. On this trip I was accompanied by the timber cruiser, and we used the canvas boats, intending to travel by water eight or ten miles, and then establish a camp from which our explorations would cover ground which might have been inaccessible if these had been carried on from the line, but we had not travelled more than four or five miles from the main camp before we came to the foot of bad rapids. On the way we had passed a bend where the river bifurcates; one branch, almost blocked up with jammed drift wood near its head makes a long detour to the east, but joins the main river again a mile and a half farther down, forming the only large island seen in

this part of its course. Along the left bank are a few large spruce, and small patches of the same timber grow half a mile farther west.

The banks of this river are seldom over five feet high and are grassy, or covered with willow, except near the rapids, where the woods extend to the water's edge; the current is very variable.

The basin drained by Smoothstone river must be very great, for I noticed that after a few hours of steady rain the water rises very fast and is liable to overflow the banks of the river.

Fearing to tear our canvas boat on the jagged rocks which obstruct the river, we decided to go afoot along the river bank and to ascertain the length of these rapids. After travelling for several hours, sometimes on pine flats, but mostly through dense willows, and seeing no slack water, we returned to the place where our boat had been left and prepared camp for the night.

The next morning the timber cruiser paddled across the river and started in a southerly direction, whilst I went on a course that would allow me to explore a strip of country three or four miles west of the river, after which I intended to turn southwesterly towards Smoothstone lake. When I had travelled for a quarter of a mile over a wooded flat I climbed a high bench on top of which are banksian pines, poplar and some birch. The country ahead was almost level, and although it was well drained in the first mile, owing to the proximity of the river, it gradually turned to marshy lands covered with decayed fallen timber, amongst which some wild hay grows. Farther on I crossed a small stream, tributary to the river, and continued my journey in tamarack, spruce and scrubby birch and thick willow over ground that was decidedly boggy. Towards the latter part of this day's explorations, I came to a much larger stream, flowing from the northwest, and to the right I could see many high hills. Then I struck southeast towards the valley of Smoothstone river which I approached through dense woods and extensive mossy swamps of tamarack and scrubby spruce. These extend to the river, where I could still hear the sound of the water rushing amongst the rocks. The natives must travel along this valley during the winter, at least, for I saw signs of their passage. The country east of the river is quite different to the section I had explored that day; it appears to be very hilly, although densely wooded. When I met my companion that night by the camp fire he was so wet from head to foot that I imagined he had attempted to cross some river. He reported having travelled over a rough country, and climbed up hill after hill with only bogs between them. When near the end of his day's journey, he had seen a large lake two miles farther on and southeast of the course he was making. On July 8 we returned to the line.

Beyond the high stony ground that defines the west of the valley of Smoothstone river, the surface of range 5 becomes more even, but one-third of this land is swamps, covered with scrub tamarack, spruce and birch, except along their edges, when the trees are somewhat larger.

Good timber is still found in patches south of the line, and consists of spruce from six to twenty-four inches, poplar from six to ten inches, and banksian pine from four to eight inches in diameter. The preservation of the timber in this locality is due to the numerous lakes, which are all connected with bogs. This has prevented further inroads of the forest fires in that direction. The soil consists of ten inches of clay loam overlying a subsoil of gravel.

Near range 6 we came to a high and broken country which continues for several miles along the east and north boundaries of township 69, range 6, leaving towards the south a sort of basin in which is a chain of lakes of varied sizes. From these hills spring many brooks discharging into these lakes, whose overflow forms a large creek which runs south in section 31, and carries to Smoothstone river the drainage of this section, and also part of the surplus water from the wet lands in the northern part of township 68, range 7, by a west tributary which empties into it in township 68, range 6.

From the report of the explorer who visited ranges 6 and 7, north of the base line, I note that he travelled close to the outline between ranges 6 and 7, passing first some scrubby land, and also a lake two miles long and from ten to sixty chains wide. He then ascended to the summit of high hills which are wooded with a fine growth of poplar measuring up to ten inches. This, however, is only a belt of large trees which runs northeast.

Continuing north, he soon arrived at a stretch of country which had been devastated by fires, and where large numbers of scorched trees were still standing. His progress was now much hindered by deadfall, but as the ground was dry and fairly level, he pushed on to the correction line, four miles farther, passing on the way a valley with a small stream, to which he returned to camp for the night. From this place he explored west, crossing in section 33, township 70, range 7, a stream running south. Near the corner of range 8 he ascended some high hills with banksian pines and small poplars. On the following day he proceeded three miles east through a burnt-over but flat country, after which he crossed another part of the same high poplar ridge which he had seen near the corner of township 69. This ridge continues north, but towards the east it slopes down to swamps and muskegs, which he also explored, meeting at intervals strips of spruce from ten to twenty inches in diameter, and saw several small streams, all flowing north. From the top of a tree he saw in that direction a great depression, which may be where Snake lake lies. He reports some high ground at five miles farther east on the correction line. This I had also noted when I was surveying in ranges 3 and 4.

The high and well defined poplar ridge above referred to would therefore be the division in the drainage to the basins of lac La Plonge, Snake lake, Doré lake and Smoothstone lake, which are all very large bodies of water.

In range 7 we encountered many swamps, separated by mossy ridges, but no grass of any kind, and for a while the ponies had to shift the best they could till we had arrived at range 8, when we discovered, between low ridges covered with deadfall, a small lake with a strip of coarse grass along its boggy shore.

In section 35 we entered a drier country with signs of a very recent fire, from which must have arisen the smoke which had previously interfered with my observations. Our cache of supplies was only a few miles south, and for a while I felt very anxious. I was therefore greatly relieved when the timber cruiser, whom I had sent to Doré lake, returned to camp with the news that this local fire had died out before reaching the shore of the lake where the cache was located. Northwards it had burned fiercely through some dry deadfalls and pine woods as far as the south edges of a muskeg, six or eight miles long, which extends in a northwesterly direction almost to lac La Plonge.

From section 35, in range 8, the line traverses the northern spurs of rough hills which extend south to Doré lake shore. Westward they cover nearly one-half of range 8 and almost all of range 9, when they descend to the low lands on which is located the new winter road opened by the Isle à la Crosse Fish company. This road is only seven miles long and connects Doré lake to lac La Plonge; the country between them is level, except when approaching lac La Plonge where it is hilly. At half-way between these lakes in another smaller one. This section is covered with tangled willow and scrub tamarack or spruce.

The portage over which the trappers used to travel between the above-mentioned large lakes intersects the base line at half a mile west of the corner of township 68, range 9. By this portage the distance between Doré lake and lac La Plonge cannot be less than twelve miles. It starts three-quarters of a mile east of the high escarpment on the north shore of Doré lake, and for about two miles it runs through a fairly level timbered country, following in places the shores of small lakes. Thence the land rises and the road crosses some high ridges, after which it descends again to a sort of pass between the hills where there is a continuous chain of small ponds, with some wild

hay along their edges. After crossing the line it turns northeast to the divide, three miles farther on. This part of the trail is blown over with dry trees, and is difficult to follow. After crossing a small stream flowing towards lac La Plonge, it ascends to a plateau covered with scrub, which the explorer classified as very good soil. This plateau spreads four miles farther to the shores of lac La Plonge, where it descends abruptly.

The country west of the trappers' trail has been devastated by fires, but on the hills, east of it, grow large poplar and banksian pine. Fair-sized spruce was seen near a few of the small lakes and also in strips on the points of Doré lake and at different places along its shores, notably on some high ridges back of two small bays on the west shore. At three miles off this shore there is a very large island whose surface rises from the water's edge to the summit of a high hill which occupies its south half. Nine other islands of different areas and separated by narrow arms of the lake are scattered in a northeasterly direct between the largest one and the head land on the north shore.

Another group of islands lies in the south bay into which Sled river discharges, whilst a few more are also located in other bays or close to the shores. All these islands are timbered.

West of the fisherman's road which leads to lac La Plonge is a strip of undulating country which extends to the centre of range 10. From there on the surface is rough, but only for a short distance, as more level land appears again beyond the ridges. This part is generally swampy, but it was noticed that many of the swamps were nearly dry, indicating that the drainage which goes south to Doré river finds a better outlet from most of the low sections we had crossed so far. Tamarack from four to ten inches in diameter were seen in several places and is the only timber of any value; the rest consists of second-growth poplar, spruce, banksian pine and birch. The soil is poor, being composed of sand, gravel and stones. At the corner of section 34 we crossed the new road to Isle à la Crosse and, one mile and a half farther, Olsen creek which rises from a lake three miles and a half north of the line. This creek is forty links wide, but was not running at the time of the survey, the water, which was very good, being found in deep pools closed up by boulders which fill the bed of this stream at intervals. This creek runs close to the line across sections 33 and 32 until it connects with Doré river four miles farther on.

In township 70, range 11, a great amount of large timber was destroyed by a fire that started early in the season and spread even to the shores of lac La Plonge. Traces of this fire were also seen north of La Plonge river, when I was travelling between the mission and the west end of the lake. The distance across is about four miles.

West of Olsen creek, and as far as Beaver river, in section 34, township 68, range 12, the soil is very good, and consists of sandy loam eighteen inches deep. The fires which swept over this section years ago did not extend their destructive work beyond range 12, where the green timber begins again and the forest continues unbroken to the valley of Beaver river which, on the east side, is bounded by high detached hills with narrow valleys, where we found many ponds fringed by hay meadows. At the crossing of the line, the Beaver river is ninety yards wide and its banks are about ten feet high. In the main channel the water is from four to eight feet deep, with a current averaging two miles an hour. From both sides of the valley the poplar woods extend to the banks of the river.

A quarter of a mile south of the line, Doré and Beaver rivers meet. At that point there is a pronounced horseshoe bend in the river, east of which is an overflow lake with extensive hay marshes along part of its shores. Half a mile above the confluence of these rivers are high sandy cut-banks on top of which some trappers erected a shanty which we were glad to use this fall to store our supplies as they were being brought down from Green Lake trading post. In that vicinity we also came across a sled road leading almost due west to Long lake, three miles and a half west of the

river. The old "freighter's road," used in the early days by the half-breeds from Green lake did not pass by "Grand rapids" but followed another valley or depression nearly parallel to that of Beaver river and only a few miles farther west. In this depression are many open swamps and lakes which, with Long lake, formed an ideal winter road, as there were very few steep hills to ascend, and also giving a most direct route when compared with the one opened later on along Beaver river, whose bends and turns it generally follows.

The Hudson's Bay company used to have a depot on the right bank of Beaver river, at the foot of "Grand Rapids," but last summer the buildings were pulled down, and the lumber collected into a raft which was floated down stream to Isle à la Crosse, so that, at present, there is no accommodation for travellers between the mouth of Waterhen river and Kennedy's house, which is about four miles south of La Plonge post. At two miles above "Grand Rapids" are some hay meadows close to the banks of Beaver river, and it was from these that the Company used to procure all the hay required by their freighters. This year they sent some of their hired men from Isle à la Crosse to put up hay for my ponies, but many of the stacks must have been built when it was raining, for, in the fall, I found this hay all mouldy and heating to such a degree that smoke was issuing from it. There are other hay flats along the banks of the river, below the rapids, but to be of any real value they would have to be cleared of the clumps of willow growing on them. They would also require considerable drainage, and it is not very apparent how this work could be carried on successfully, in most cases, for their surface is very little higher than the present level of the water of Beaver river, and the surplus water, which is the overflow from springs rising in the hills bounding both sides of the valley, is held back by an embankment whose top, covered with thick willow, rises six to eight feet above the level of these meadows.

Between "Grand Rapids," which is five miles north of the correction line in township 67, range 12, and the confluence of Beaver and Doré rivers, the banks are generally six to twelve feet high except in two places, where, on the west side, are high sandy cut-banks, the highest ones beginning near an Indian trail which leads northwesterly to Long lake.

The country west of this portion of Beaver river is broken by steep hills, on which banksian pine, from six to ten inches in diameter, is the prevalent timber. This hilly country goes three miles and a half farther west to the depression of Long lake, a body of water of variable width but nearly eight miles long. The line struck this lake, which lies almost due north and south, near its center, and three-quarters of a mile south of its narrowest part, which is less than fifteen chains wide. Here we had intended at first to ferry the camp outfit on rafts and swim the horses, but after carefully examining both shores which are simply quaking bogs merging into clear black mud far into the lake, I saw the danger of risking our ponies in such a treacherous place where they would certainly have sunk and been drowned. To go around the south end of this lake and its many deep bays meant the opening of at least twelve miles of road, part of which would have to be brushed or corduroyed.

After the shores of the lake had been further explored, firm ground was found north of the Narrows, and although the lake is quite wide at that spot, I did not anticipate any trouble in swimming the horses over to the opposite shore provided no wind should rise on the lake while crossing.

While a strong raft was being built for transporting the camp outfit and supplies across the lake, a path was cleared around the deep bay, south of which our camp was situated, in order to bring the pack animals to the crossing. When the time came to send the horses across, several Indians who had spent the summer in this vicinity offered their services, which were gratefully accepted.

After the whole outfit had been transferred to the west shore of the lake, the survey of the line was resumed. In section 35 of range 13, it intersected again one

Photo by G. H. Blanchet, D.L.S.
Nineteenth Base Line West of the Fifth Meridian, Across Christina Valley.

Photo by J. S. Galletly, D.L.S.
Camp in Township 109, Range 14, West of the Fifth Meridian.

of the deepest bays of this lake. Beyond the bay, the country is a succession of wooded ridges with great marshes almost to Burnt river, a swiftly running stream a chain and a half in width, and with numerous rapids. It flows out of Burnt lake at a point on its east shore, one mile south of the line.

This large lake lies partly in townships 68, ranges 14 and 15, and extends south to the north boundary of township 67, range 14, while northwards its shore runs one mile beyond the base line. It is very shallow, especially along its west shore, where wide mud banks spread far into the lake.

DESCRIPTION OF THE COUNTRY WEST OF BEAVER RIVER.

Strips of rolling land, separated by narrow but deep valleys, following a north and south direction form the principal feature of the country west of Beaver river. Two of these valleys deserve special mention.

The first one west of the Beaver valley follows closely the outline between ranges 12 and 13 for fifteen miles, but in section 24, township 70, range 13, it turns northwest, and eight miles farther on it meets the other valley in which Burnt river flows almost due north to Canoe lake. The valleys join at the north boundary of township 70, where Burnt river receives its principal eastern tributary. From the confluence of these streams the main valley spreads out to the nearly level section of land surrounding Canoe lake, where there is an Indian village.

In the first-mentioned valley, there are, besides Long lake, three others from two to four miles long and connected by streams that are navigable for canoes. There are small islands in every one of these lakes. The outlet of the most northern one flows northwest for five miles before joining Burnt river. Soon after it leaves the last lake the only rapids which interfere with its navigation occur. Through these, the Indians have made artificial channels by removing a large number of boulders, but as, at the time of our visit (October 11, 1912) the water was very low, it was not advisable to risk the canvas boats in such places, and the exploration of the country to the valley of Burnt river had to be done on foot. Below the rapids, the creek winds in a valley from a quarter to half a mile wide. In several places I saw some hay meadows along both banks, although most of the bottom lands are covered with clumps of willow. This creek is about three feet deep; its banks are nowhere high and its current will average two miles an hour.

The prominent long range of hills rising at variable distances from the east shores of all these lakes is sparsely timbered with small poplar and in many spots they appear to be covered with light scrub only. The country adjacent to their western shores is low and swampy, especially along the banks of the stream in sections 31 and 32, township 69, range 12, which joins the second and third lakes. North of these swamps the land rises gradually and at the creek the benches attain an elevation of forty feet above the bottom of the valley. Fires have cleared large areas of all timber and moss; the soil is remarkably free of stones, and consists mostly of clay loam. Near the valley of Burnt river the tops of the benches support a good growth of poplar, and I also saw some spruce, cotton-wood and birch nearer the creek. On the north side there is quite a high ridge where banksian pine is the most common timber.

The valley of Burnt river is covered with tangled willow and alder, which are almost impenetrable.

South of the swampy land found in the northwest quarter of township 69, range 12, there is yet much green timber, generally large poplar and pine. The forest continues south of the base line.

Between Burnt lake and the seventeenth correction line is a wide section of low lands, drained by two large streams and their tributaries. Both streams enter the lake at its south end, and their estuaries are only two miles apart. The first one is

fifty yards wide, has low banks and for a distance of four miles from the lake shore, its current barely perceptible. At that point it branches. Although the left branch is the wider and deeper of the two, it has much the appearance of a slough receiving the overflow or seepage of the marshes which adjoin it. I believe it branches off in every direction among these marshes as is often the case in this country with streams in which no current can be detected. However, I did not have time to investigate this matter as it was then October and the days were getting shorter, and I had to explore the other branch which had well-defined banks. We had not paddled up that last stream very far before we noticed that the current was gradually increasing, the stream all the time winding across a nearly level country covered with low bushes. At one place we saw a few spruce measuring up to thirty-six inches in diameter and from the time which had elapsed since we passed the forks I concluded that we must have been then very close to the correction line. Before turning back, the explorer climbed the tallest of these spruce and from his observation point he saw some hills about two miles to the southeast and others considerably farther in a southwesterly direction. The rest of the country is described as flat and covered with small willow, bi· ·h and other low bushes. This low country is probably the continuation of the open and impassable bogs we had encountered on the other base line. Where we turned back, the stream was forty links wide, about five feet deep, with a sandy bottom. Its banks never rise above five feet and were everywhere covered with a thick clump of willow. The water was very clear and teeming with whitefish.

On September 12, I left my camp at Long lake and travelled to Beaver river, and thence proceeded by boat to La Plonge mission, twenty-eight miles farther down stream in order to buy some provisions and get my mail, which through a misunderstanding had been carried north instead of being delivered at the line.

A short distance above La Plonge village, Beaver river divides into several channels. To reach the mission landing one must follow for a distance of two miles the most eastern one, less than a chain wide in places, and very tortuous. This branch of Beaver river approaches a high and well-wooded ridge where it meets La Plonge river which has to be ascended a considerable distance in order to make the landing.

An alternate route, sometimes used by the Indians who go to the mission, is by portaging the canoes across the hay marshes which are in this vicinity the principal feature of the Beaver valley.

La Plonge river runs close to the foot of the bench where the orphanage and the other buildings of the mission stand. These are lighted by electricity and supplied with water for domestic purposes by power derived from La Plonge river. The same water-power drives the machinery in the saw-mill and planing-mill which belong to the mission. In this neighbourhood there is a large acreage under cultivation, part of it being in gardens where all kinds of vegetables grow luxuriantly, and the rest in fields of oats and barley that never fail to mature. Hay in unlimited quantities can be procured from the flats along Beaver river.

After securing my mail and purchasing supplies, I proceeded at once to the line, where I arrived on September 16.

All through the lands explored last summer, most of the timber is second growth. There has been very large spruce in many places at some former time. But fires have swept over this country so often that now there is very little milling timber, although in some sections the trees grow large enough to be suitable for railway ties, telegraph poles, piles, etc.

Much of the smaller timber could be turned into pulp. It has now been demonstrated from experiments that the banksian pine (so commonly met in this northern country) is entirely suitable for the manufacture of newspaper.

The immediate source of revenue for many years to come will be principally derived from the fishing industry. The companies which are licensed by the Government to carry on this trade, are yearly extending their operations by opening new

routes to lakes which are known to be well stocked with the best varieties of fish, but which, owing to the lack of roads, were inaccessible except to a few nomad Indians. The catch of whitefish alone, in the northern part of this province was last winter estimated at three million pounds, which sold at a very remunerative price. Lake trout, which a few years ago was not marketable, now meets with a good demand, and as it is only caught in certain lakes the price is sure to rise; of the other varieties, such as pickerel and pike, which are found in all lakes and streams, enormous quantities are annually disposed of, but by the wise protective laws enforced by the provincial authorities, there is no danger that these lakes will ever be depleted. So far this industry has been carried on only during the winter, but some of the railway companies are beginning to see what a large revenue this new industry can be made to pay them, and consequently they are preparing to supply specially constructed cars to handle properly this food product at all seasons.

The fish industry is yet in its infancy in the province of Saskatchewan, but it is sure to develop in the near future, insuring an ever increasing source of revenue to the Government and a good income to the parties who have invested their capital in the enterprise.

The Isle à la Crosse Fishing company, who are the leaders in developing this industry here, have spent large sums of money in opening a winter road to La Plonge mission, one hundred and ten miles north of Big River. Their road affords a most direct route and the easiest grade for the increasing northern trade, and the Company is encouraging the freighters to travel over it by building at shorter intervals new stopping-places and changing the original location of these where the supply of water sometimes failed during the coldest weather.

The manager of this Company has offices at Big River station, which is the terminus of a branch of the Canadian Northern railway and the distributing point in this province of the output of the Company's fisheries.

On October 5, the survey of the eighteenth base line had been carried to the west shore of Burnt lake, near the middle of range 15, but poor and insufficient grass, since we had left Long lake, added to the inclemency of the season, was playing havoc with my pack animals, which were gradually weakening under the strain put on them in transporting our outfit. Under such conditions, and with the knowledge that the hay put up for them in the Beaver valley was too much spoiled to be of any use, I was compelled to suspend my operations for the season. When returning to the valley of Beaver river the men widened and otherwise improved the pack-trail, so that it could be used for sleds later on, taking advantage for this purpose of all open swamps and muskegs.

A few miles above "Grand Rapids" our road connects with the freighters' road to Green Lake.

On October 22, when I arrived at the mouth of Waterhen river, I was able to procure from a squatter some loose hay for the ponies, which were kept there till the morning of the 24th, for a much-needed rest, and also because we had been informed that before they could reach Green lake (a three days' journey) they would have to feed on what frozen grass they could pick along the road. I also had to rent a shack and store part of our outfit which was too cumbersome for the number of horses that were still fit for packing.

On October 24, we crossed Waterhen river and continued our journey southward over the Government road opened last summer through the woods along the left bank of Beaver river, as far as Waterhen river.

This road makes a junction with the Green lake trail south of Beaver river. It is fairly straight, well located, and when graded will be of great assistance to the incoming settler now that this section of country is all subdivided.

On October 24, we camped for the night at Rat creek, and the horses were driven to some hay marshes up the valley.

In the afternoon of the next day we came to the valley of Beaver river. Although there was, north of the river, an extensive hay meadow where our ponies might have had plenty of grass, such as it was, I did not consider it wise to stop at this place. In the early part of the day I had seen much floating ice on the river and I feared that if the outfit did not cross immediately, we might later on be much hampered, if not actually stopped by it. So we went to camp on the opposite side of the river, everyone wading the best he could through the icy waters which, in places, reached well above the waist. At this crossing there is a rapid and the ponies had to follow a circuitous way before they came to the river bank.

Last summer the Dominion telegraph from Battleford was extended this far, and will soon be continued north.

Quantities of telegraph wire have been shipped here, and many telegraph poles have also been handed to the new road, ready for continuing this line to Isle à la Crosse.

Lately a branch of this line has also been built to Green Lake trading post, and I am informed that a telegraph office is now opened at this post.

On October 26, we arrived at Green Lake, where arrangements were made with the mail carrier who was going to Big River for carrying part of the men's baggage so as to lighten the ponies. We were six days on this trip. At Big River we took the train to Prince Albert, where we arrived on November 5. My party having been padi off, I started to make preparations for continuing my surveys during the winter.

GENERAL REMARKS.

Last season was a particularly bad one from a surveyor's standpoint. Unfavourable conditions for observing, due sometimes to smoke but more often to long spells of cloudy weather, interfered much with astronomical work, and for that reason I did not get as frequent observations for checking the bearing of the line as I desired.

In the district where I was surveying, frosts occurred during the nights of June 4 and 5, and again on the nights of July 16, 17, 19 and 20, when ice a quarter of an inch thick formed on water kept in receptacles in the tents. These frosts were also felt at La Plonge mission, where the barley suffered to a certain extent, although oats stood them well.

No minerals were found along the lines surveyed, but the abnormal declination of the magnetic needle in the first ranges west of the third meridian would indicate the presence of mineral deposits along a belt which extends southerly across the seventeenth and sixteenth base lines, because the same irregularities were noticed there at the time I surveyed these lines.

Beavers were seen at work on all streams in the country adjoining the third meridian. Bears are quit common, also coyotes, foxes, lxnx, marten, mink and weasels.

APPENDIX No. 44.

ABSTRACT OF THE REPORT OF B. H. SEGRE, D.L.S.

MISCELLANEOUS RESURVEYS IN SOUTHERN SASKATCHEWAN.

I organized my party at Regina and, on August 31, 1912, left for Raymore to investigate the duplicate monuments reported to be found at the northeast corner of township 27, range 19, west of the second meridian.

Raymore is a thriving settlement of about two hundred inhabitants, situated on the Grand Trunk Pacific railway, and was at the time of my survey the headquarters of the Pearson Land Co. There are no water-powers or streams near, the water supply being obtained from wells. The soil in this locality is a heavy black loam, producing excellent crops, the average yield of wheat being in the neighbourhood of thirty-five bushels per acre. There is a considerable amount of scrub in this locality and, the district being new, very little clearing has been done.

On completion of the investigation which was delayed by continuous rains, and having destroyed the erroneous monument as instructed, I left for Yorkton by way of Melville, on September 10. My work there was the investigation of portions of the northeast quarter of section 34, township 26, range 2, west of the second meridian. This was completed on September 17, and I returned to Yorkton on the following day. Yorkton is one of the important towns in Saskatchewan, being situated on the branch of the Canadian Pacific railway from Winnipeg to Edmonton and on the Grand Trunk Pacific branch line to Canora; it is expected that the Canadian Northern railway will also enter the town shortly. The town is lighted mostly by electricity and has also a municipal acetylene plant. There are several banks and churches, and the International Harvester Co. have just completed a large warehouse and distributing plant. The only river in the vicinity is a small stream called Whitesand river. The sewage therefore has to be treated in a septic tank before being allowed to flow into this river.

I left Yorkton on September 19 by way of Saskatoon for Duck Lake settlement, arriving there on the 20th. This is a small settlement of about seven hundred inhabitants on the branch of the Canadian Northern railway from Regina to Prince Albert, and is the centre of a large and prosperous farming community; there are several churches, a bank and an industrial school for the Indians located there. On September 24, I left for township 46, range 3, west of the third meridian, to investigate the conditions in sections 22 and 15 as a result of duplicate monuments being on the ground. I made the necessary changes as instructed, completing them on November 19. The soil in this locality is of a light sandy nature, the district is not being settled rapidly on account of the thickness of the scrub, many sections requiring a great deal of clearing before extensive farming operations could be carried on. There are numerous sloughs in the vicinity of township 46, which would make the locality more suitable for the raising of stock than for grain, as ample hay could be secured along these sloughs for feeding in winter. On account of the trouble arising from the duplicate monuments, no road improvements of a permanent nature are being carried on, and these are badly needed, as the farmers have to wait for the snow in order to move their grain for shipping, thus losing the advantage of securing the better prices of the early markets.

On completion of my work at Duck lake, I left by way of Saskatoon for Renown. I arrived there on October 4 and made an investigation of the width of the road allowance along the correction line between township 30, range 27, and townships 31,

ranges 26 and 27, west of the second meridian. I corrected the error along the south boundary of section 6, township 31, range 26, and made investigations which showed that the error extended along the correction line both east and west from the lines ordered to be surveyed. The district is well settled, and, being very near the railroad, should go ahead very rapidly. The soil is of very good quality but is underlaid with large granite boulders. Grain is shipped from Renown on the Canadian Pacific railway, but most of the settlers go to Watrous on the Grand Trunk Pacific for provisions, etc., hence there is only one store and a lumber yard at present in Renown. The water in this locality has an alkaline taste, but is easily obtainable by sinking wells.

Having completed the above investigation, I left for Davidson on October 12 by way of Saskatoon and arrived there the same night. On the 14th, I went to work in township 28, range 27, west of the second meridian, a distance of twenty miles from Davidson. The work here consisted in investigating the error in the position of a witness mound marking the northeast corner of section 16. This error was located in the southeast quarter of the above section and on completing the lines around the block I found an error of one chain in the lengths of the east and west boundaries of this block. As the lands were patented and the owners of the southeast and southwest quarters of section 16 would be losers if the quarter post on the east boundary only were changed, I submitted a report to this effect and on receipt of a favourable reply on October 26, I returned to the township and made the necessary corrections suitable to the different owners. I also placed posts at the quarter section corners where none had been erected at the time of the original survey, through the presence on the ground of sloughs which since have dried up.

This locality is very thickly settled to the south and west of this work but, as the land rises to the north and east and is very much broken up by valleys, settlement is retarded for a time; also the lack of railroad facilities is keeping the locality back, the drive to Davidson being twenty miles, with one steep climb out of the valley of Arm river. The drive to Imperial is only fourteen miles, but the road is very rough, hence Davidson is preferred by most of the settlers. All the sloughs here have dried up considerably, and many farmers experience difficulty in securing a good supply of water except at a depth of from sixty to eighty feet. Davidson, the main outlet for the grain of this community, is a very enterprising settlement of about 800 inhabitants; it owns an electric lighting plant, power being generated by a gasolene engine. On October 28, H.R.H. the Duchess of Connaught laid the corner stone of a hospital to be erected there. There are several churches, two banks and five grain elevators; I was also shown some samples of brick made of clay obtained from a farm a few miles out of town and they were very good indeed. It was the intention of the promoters to interest capital in the venture and get started manufacturing brick as soon as possible.

Having completed these investigations, I returned to Davidson on October 19 and on the 21st left for Rosemae to investigate a lake on the southeast quarter of section 16, township 25, range 3, west of the third meridian. As a result of my investigation I found that although this quarter section was lower than the surrounding land, the water had dried up since the original survey was made. There was a rich crop of vegetation growing on the quarter and hay had been cut from it for many years. From present appearances it is not likely that this quarter will ever be under water again, and it is therefore quite suitable for farming purposes. I completed this work on October 24 and, returning to Davidson, I was engaged in preparing sketches until the receipt of your telegram of October 26 when I returned to township 28, range 27, and made changes as instructed. I completed these changes on October 28, and returned to Davidson.

On October 29 I packed my outfit and left for Aylesbury. The following day I drove out to section 2, township 24, range 27, west of the second meridian, to investigate an error on the east boundary of section 2. This error I located in the

northeast quarter of section 11, and found that it had been carried through to section 2. The lands there were nearly all held by persons residing outside the district and considerable trouble was experienced in locating the owners in order to have the petition signed. I also had some trouble in getting the present holders of sections 1 and 2 to come to an agreement over some improvements affected by the change. Having adjusted these matters and obtained the signatures to the petitions I left for Caron by way of Regina on November 6.

I arrived there on the 8th and left the next morning for township 16, range 30, west of the second meridian, but on receipt of a wire on November 13 instructing me to return to Duck Lake, I immediately drove out for my outfit and assistant and left for Duck Lake settlement on November 14. On reaching Regina after completing my work at Duck Lake I had to hire another assistant owing to my former one leaving. I next left for Mortlach on November 23 and for township 16, range 30, on the 25th. The work there consisted of destroying a duplicate monument marking the northeast corner of section 24 and this was done after due investigation. The surface is very rolling in this township and rises sharply to the east. It is, however, thickly settled and the soil is a good loam, producing exeellent crops. This township may be reached from either Caron or Mortlach, small towns on the main line of the Canadian Pacific railway.

I completed the above investigation and, having received instructions to extend the subdivision lines across the dry portions of Pelican lake which lies north of Mortlach, I proceeded to that vicinity on December 2 and started on the extension of these lines. I found the southeastern end of this lake completely dried up, but the soil being alkaline the growth of grass is not heavy; the middle of the old bed in township 18, range 30, is still a little marshy but by draining towards the southeast the whole bed should provide good pasture land, and, after a few years ploughing, it should begin to produce grain. I carried these lines up to the third meridian and abandoned further operations owing to the depth of the frost retarding the progress of mounding.

On December 16, I left Mortlach for Pennant, where I arrived on the following day, to investigate an erroneous monument on the north boundary of section 10, township 18, range 17, west of the third meridian. I corrected this after noting improvements affected and returned to Regina on the 19th.

I then proceeded to Yorkton to obtain signatures to a petition for re-establishing the northeast corner of section 34, township 26, range 2, west of the second meridian.

Having received instructions to close operations for the season, I proceeded to Winnipeg where I stored my outfit. I then left for Toronto, arriving there on January 5, 1913.

APPENDIX No. 45.

ABSTRACT OF THE REPORT OF F. V. SEIBERT, D.L.S.

MISCELLANEOUS SURVEYS IN SOUTHERN SASKATCHEWAN AND ALBERTA.

The miscellaneous surveys on which I was engaged in the southern parts of Alberta and Saskatchewan were of widely different natures. They consisted in restoring and establishing obliterated and lost monuments; locating and correcting, where possible, errors in the original surveys; resurveying the beds of a number of prairie lakes which had dried up since the original survey; traversing the shores of lakes where the beds have sensibly altered since the original survey; investigating all manner of communications received by the Department from the settlers with reference to surveys. Briefly, the work consisted of those surveys and investigations on which it was not thought advisable to place a regular party and which could best be done by a surveyor and his assistant.

This work took me over the greater part of the prairie portions of Saskatchewan and southern Alberta. On every hand I found indications of prosperity. The most optimistic reports in the past of the possibilities of this country are being realized. Railway development is taking place in almost every portion of the country, improvements were noticed on every hand, and towns are springing up as rapidly as the railways permit. In a few months a settlement of one, two or three hundred people springs up where before there was nothing except the bare prairie. This is generally the case just as soon as freight can be taken over the newly laid steel and sometimes even before. But rapid as the development is, it cannot in every instance keep pace with the needs of the country. We covered some sections of the country where the soil and climatic conditions were of the best and where all the available homesteads were taken up. Yet it was so far from railway facilities as to make the growing of grain for sale a losing undertaking. In some cases the settlers had to haul their grain seventy-five to eighty miles to market. In the greater part of the country, however, the railways are following the settler very closely and in most cases just as soon as he has any grain to sell he has a railway to take it to market.

Covering as much of the country as I did I could not help noticing the excellent class of people who are making this country their home. Many of them were old pioneers, though more often sons and daughters of old pioneers of the Dakotas to the south, or Ontario to the east, or of other portions of America. Many of them brought money and settlers' effects into the country, while others came with almost nothing. Those who came with sufficient for a start were able to take advantage of the low price of land and to secure large holdings, while the poorest were able, after a few years, to extend beyond their original homestead and pre-emption.

This reaching out after more land in many cases leads to careless farming. A number of farmers in different sections of the country are trying to farm too much, with the result that their land is impoverished by weeds and their profit for any individual year is not as much as it would be on less land properly cultivated.

One other thing noticeable is the lack of mixed farming. The growing of grain in the past has been so profitable, and the work so much more desirable than was the raising of stock, that the latter kind of farming has been neglected. These things will no doubt right themselves in time. The increase in the price of stock has already started many into stock farming, and a few years will see a decided change.

The success of those already in stock farming is sure to have its result.

Besides our regular survey work observations for magnetic declination were taken wherever possible.

APPENDIX No. 46.

REPORT OF N. C. STEWART, D.L.S.

SURVEYS IN THE RAILWAY BELT.

VANCOUVER, B.C., February 10, 1913.

E. DEVILLE, ESQ., LL.D.,
Surveyor General,
Ottawa, Canada.

SIR,—I have the honour to submit the following report of my season's operations in the railway belt of the province of British Columbia.

I left Enderby on May 14, 1912, for my first work in township 18, range 7, west of the sixth meridian. The wagon road between Enderby and Mabel lake runs through this township. This road has been widened out and graded during the past season, and is now in good shape, but the soil through which it passes is a heavy clay, which makes it very muddy and sticky after a rain. Owing to the numerous logging operations carried on in this vicinity and on Mabel lake, and to the large number of settlers along Shuswap river, this road is very much used. A branch road, built by the settlers, which leaves the main road about seven miles from Enderby, enabled me to bring my supplies to section 30 with wagons.

I completed the surveys of four sections in the northwest part of the township. A few small benches of good land were found, and the hillsides were covered with grass, making them good for grazing purposes. The soil is a light sandy loam, with a gravel and drift-rock subsoil. The timber has been nearly all burnt off, but a few large fir and bull pine remain. The upper benches in this valley have been cultivated very little, but some good results have been obtained, especially in the raising of vegetables, hay, grain and small fruits. The climate during May and June was all that could be desired, warm days with cool nights but no frost, and only a few days of rain.

I ran two miles of line on the east boundaries of sections 6 and 7 in township 19, range 7, but found only rugged and worthless mountain tops, from which the timber had all been burnt.

On June 4, I moved across Shuswap river to the northwest quarter of section 23, township 18, range 8. A branch road was being built from the Mabel lake road to Trinity valley, a bridge having been erected over Shuswap river on the east boundary of section 22. This road was completed in the fall. The soil along the river is a rich clay loam, which produces hay, grain, vegetables and fruits in abundance. On the benches along Trinity creek a light sandy loam with a gravel subsoil was found. No one has tried to cultivate these benches up to date. The country west of Trinity creek is covered by some marketable timber, but to the east of this creek a bush fire occurred during the previous summer which destroyed most of the timber. Trinity creek has several high waterfalls which might be used for power sites, if the water supply was sufficient in the dry season. More rain falls along Trinity creek than on the north side of Shuswap river.

Game is plentiful in this neighbourhood; black bears, deer and blue and willow grouse were frequently seen.

On June 15 we took the train at Enderby for Field, where we camped in one of the most picturesque spots in the Rockies, on the northern slope of Cathedral mountain, and in direct line with the famous Yoho valley. My work here consisted chiefly in retracements and making ties to the Canadian Pacific railway survey.

The only industry in this part is mining. The Monarch mine is situated on Mt. Stephen, in a very romantic locality. About twenty men were employed, and the mine was said to be paying dividends. The ore is silver-lead.

The old grade of the Canadian Pacific railway has been made into a wagon road, thus affording a means of travel from Field to Hector, and a good road has been constructed from Field up the Yoho valley for the use of tourists. We had excellent weather during our two weeks' stay. We returnedto Moberly on July 1 and commenced regular subdivision work in township 28, range 22, west of the fifth meridian. The soil in this township is a sandy loam, with a clay loam subsoil in many places, which should produce hay, grain, small fruits and vegetables. The land of a similar nature which has been cultivated around Golden produces good crops. A hill between 200 and 300 feet high is found along Columbia river; back of this hill is a more or less rolling bench land which varies from about a mile in width at the south boundary of the township to over five miles at the north. East of this bench rise the rugged slopes of Moberly peak and the mountains to the north of it. Practically all the trees have been burnt, and a thick second growth covers the fallen timber, making travelling and clearing difficult. A road has been built from Golden to Blaeberry river, a distance of nine miles, and a branch road was built by the squatters from Moberly to section 11. A trail from Moberly up Blaeberry river is utilized by the trappers and settlers along that stream. The farmers along Columbia river are very prosperous, mixed farming being found to be the most suitable for this region. The meadows along Columbia river afford a supply of hay for feeding the stock during the long winter. Quite a few trappers still operate in this district, and large game such as bears (black and grizzly), moose, deer, caribou, goats, coyotes and cougar are plentiful; rabbits, grouse and ducks are fairly numerous. Good fishing is to be had at places along Columbia river, especially at the mouths of the clear-water streams from the Selkirks. Much rainy weather was encountered during July and August. A large forest fire occurred in this township and those to the northwest in June, and another large fire destroyed much valuable timber south of Golden. I completed the survey of all land suitable for agriculture in this township east of Columbia river on August 10.

Leaving Beavermouth on August 12, in three heavily loaded canoes, we drifted down to the mouth of Gold river in township 32, range 26, west of the fifth meridian, in about six hours. At the mouth of this river a large flat was found composed of large marshes from which hay could be cut and which were subject to overflow from Columbia and Gold rivers. Around the marshes, large timber, chiefly spruce, was found. Gold river has its source in some of the highest and most picturesque peaks of the Selkirk range, and the melting of the numerous glaciers in these mountains on a hot day causes the water to rise at the rate of about a foot an hour, and the cool nights following cause it to subside almost as rapidly.

On August 28, we moved camp to Bush lake by going up Bush river to the creek and thence to the lake. Here we completed two miles of the belt limit. The country around this lake is all heavily timbered. The land in this township is not very suitable for agricultural purposes, but the wild hay will be valuable when logging operations commence on the numerous timber berths in this territory. The proximity of the glaciers has a bad effect on the climate, and we had very wet weather during our stay on the lake.

Bush lake is at present an ideal spot for a sportsman. There were hundreds of ducks and geese there and its waters were full of rainbow trout. Fur-bearing animals such as beaver, mink, marten, and skunks are plentiful. Two black bears were seen, and the tracks of numerous caribou and goats are to be found on the mountains. Combining this with the fine scenery, the unsurpassed mountains and the ease of canoe travel, I believe one could not find a better place for an outing.

We left Bush lake on September 6, and proceeded up Columbia river to section 17, township 31, range 25, west of the fifth meridian. At two large bends in the river there, I found some land which is suitable for agricultural purposes, although the area of this land is not very great. The soil is a sandy loam with a clay loam subsoil. I examined part of this township to the northeast of Columbia river and though I found no more land suitable for farming, I did find some excellent timber

consisting of large fir, pine, cedar, spruce and balsam. Numerous grouse and ducks were seen, and I might also mention the presence of mosquitoes.

On September 11, with one canoe, I left for Beavermouth, Mr. Johnston following next day with the crew and outfit. We left that place and arrived in Rogers Pass on the 13th.

The survey of the townsite of Rogers Pass was completed on September 21, after which we returned to the Enderby district to complete the surveys there before the snow came. Our work in township 17, range 10, west of the sixth meridian, was reached by wagon from Armstrong. This work was chiefly retracement. The productiveness of the soil in this neighbourhood is shown by the prosperity of the farmers who all have good homes, large barns, fine horses, cattle, sheep, &c. The orchards produce more fruit than can be taken care of, and many acres of potatoes have been left until spring for harvesting owing to an over supply. The growing of celery is becoming a specialty with some of the farmers.

From this township we proceeded by wagon to Deep creek valley where we found a very prosperous community engaged in mixed farming. The land subdivided in township 19, range 9, is all on the west side of the valley. The country had all been burnt over several years ago and a very dense second growth has sprung up. The soil in the bottom lands is a clay loam and on the benches and side-hills it is a sandy loam with numerous rock outcrops. The settlers are very optimistic about the productiveness of the soil in this valley. As the altitude is considerably higher than at Armstrong very little fruit growing has been attempted, however it has been shown that the hardier fruits can be grown. Snow fell on October 19, and all the month was very wet. Willow grouse were very plentiful.

On October 24, I again moved to township 18, range 8, and surveyed the north boundary of section 14, after which we went to township 20, range 8, where we made surveys in sections 15 and 22. A few small benches of fairly good land were found, the soil being of a light sandy loam suitable for growing fruit and vegetables. The fruit farmers in this district are very prosperous.

The towns of Enderby, Armstrong and Salmon Arm are in a flourishing state owing chiefly to the farming and lumbering industries. The prospect of the coming of the Canadian Northern railway into Armstrong has enlivened that town considerably and the completion of the road will no doubt advance the prosperity of the settlers since it will give them another outlet for their produce. The lack of sufficient transportation is at present the principal drawback to this neighbourhood.

We moved again to the vicinity of Golden to traverse part of Columbia river in townships 28 and 29, range 23, west of the fifth meridian. This work was made very easy by the low water. In these townships the Columbia is broken into numerous channels, and the islands are all timbered with spruce, jackpine, balsam and cypress. The large timber was logged off several years ago. The soil on the islands is a sandy loam with a clay loam subsoil and therefore should be suitable for agricultural purposes. I also surveyed some of the bench land in township 29, range 22, and township 29, range 23. This bench is a continuation of the bench land of township 28, range 22, and extends from Blaeberry river to Waitabit creek, a distance of about six miles and averages about one and a half miles in width. The soil is a light sandy loam with a gravel subsoil and should produce good results when cultivated. The timber has all been killed by fire, the most recent fire having been started last spring. Numerous settlers are trying to locate on this land which shows that it appears suitable for farming.

On December 4, I decided to disband the party on account of the depth of the snow and the dangerous condition of the river for canoeing.

I have the honour, to be, Sir,

Your obedient servant,

N. C. STEWART, D.L.S.

APPENDIX No. 47.

REPORT OF P. B. STREET, D.L.S.

SURVEYS IN SOUTHWESTERN ALBERTA.

TORONTO, ONT., January 3, 1913.

E. DEVILLE, ESQ., LL.D.
Surveyor General,
Ottawa, Canada.

SIR,—I have the honour to submit the following general report of my field work during the season of 1912.

I left High River with my party on May 24, and drove to township 5, range 17, west of the fourth meridian, where my first work lay. This township is open undulating prairie, and is now partly fenced by settlers. Owing to the dry atmosphere which prevails in this district, the settlers have been very unfortunate with their crops up to the present time, and unless they adopt mixed farming their future success will be very uncertain. We retraced all the interior lines of this township and, owing to an error in the west boundary, we were obliged to carry the retracement into the adjoining township to the west.

On completing this work, I moved to township 2, range 19, west of the fourth meridian, and retraced some section lines there. This township, with several others in this vicinity, is held under lease, and an occasional rancher's house is the only sign of settlement. Being situated on Milk river ridge this township is very rough and hilly, and owing to the high altitude it is doubtful if it will be of any use for agriculture, although it is ideal for ranching. We spent only a few days there, and then crossed to Cardston, reaching that town on June 24. I sent the outfit across country through Standoff, Pincher and Cowley, to a camp ground on Oldman river, and went to Lethbridge to get some axemen for the work in the mountains, as I had been short three men since I organized. Finding no suitable men in Lethbridge, I went to Calgary, and secured three men there. I was unable to secure a good packer, which proved a great handicap later as I was forced to train my teamster to do the packing, and this meant that I did most of it myself.

On rejoining my party north of Cowley, we proceeded up the trail from Cowley to the Gap, and from there to McEwen's ranch in section 6, township 12, range 3, west of the fifth meridian. Our trip was delayed several times by bad roads which had to be repaired, and by the rains which came every other day. The land in this district is very rough and broken. A series of ridges run north and south, with narrow valleys between them, affording very little land that could be used for settlement. The wagon road from Cowley runs as far north as section 12 of township 12, range 4, and a pack trail continues from this point up Livingstone river to its head-waters, and over the divide to the head-waters of Highwood river. A railway line was surveyed up this valley, but, as no coal lands of any importance are found along Livingstone river, it is very doubtful if this line will be adopted. We commenced our surveys here on July 3, but we were much delayed by the incessant rains which fell during the early part of that month. Luckily for us the timber in this township, though nearly all fire-killed, was not large, and the men, although unused to the mountains, soon got accustomed to the long walks across country. Creeks are very numerous in this township, and I was much impressed with the abundance of pasture which we found along the creek valleys. The grass grows very rank in the mountains, reaching a height of three or

four feet at the end of the season. If the ranching commission decide to lease the forest reserve, there will be ample pasture for thousands of cattle. A fine crop of timothy hay was raised on McEwen's ranch in section 6 this year, in spite of the bad weather.

On completing the work in this township we moved up the northwest branch of Oldman river, and camped in section 9 near the buildings of the Great West Coal Co. A pack trail from this point follows the river to its head-waters, and is much used by the Indians of the Stony reserve, but like most Indian trails it was made very crooked to avoid as much cutting as possible. I looked over it and decided to abandon it and cut a wagon road up the valley to the west boundary of the township. This was accomplished without much difficulty, and we moved into section 36 of township 12, range 5. We found the country much more mountainous in range 5, and the hills had steeper slopes than we found east of Livingstone river. This country was fire-swept two years ago, and very little green timber can be found now for miles on either side of the river. The country is mostly covered with large windfall, which made walking to and from work very arduous. Considerable bare rock is found on these ridges, black and grey shale and conglomerate being the commoner kinds, and coal outcrops could be seen on the tops of most of the hills and ridges. We saw numerous deer in this locality, but small game such as partridges and rabbits were scarcely seen at all. The fishing was all that could be desired, there being no difficulty in catching a dozen or more any evening after supper.

We moved up Dutch creek early in September, and camped on the creek near the west boundary of township 11, range 4. This country did not suffer very heavily from the big fire two years ago, and large quantities of excellent spruce timber are found in sections 6, 7 and 18 of this township. These areas are all held under timber berths, but no cutting has been attempted up to the present. Dutch creek is too small for driving logs, and a wagon road will have to be built up the creek to enable the owners to get their logs out. We found the windfall in this locality to be the worst we had struck all season, and a great deal of valuable time was lost in walking to and from work. I had anticipated putting in some flying camps in this locality, but the time lost in cutting pack trails would have been too great. We had several snowstorms during September, which delayed the work, and made the chopping disagreeable.

On October 7 we moved up Racehorse creek to the mouth of Daisy creek, there being a wagon road to that point, and a pack trail from there to Lille. A telephone line was strung from Lille to the fire ranger's house, near the mouth of Racehorse creek this season. Our work in this vicinity consisted in surveying some mining claims on the western slope of the Livingstone range, and for the first time during the season we found the country so rough that we were forced to run quarter-section lines instead of the regular section lines. There was about six inches of snow on the hillside, which made climbing difficult and, at times, dangerous.

On completing the work here we moved through the Gap to township 11, range 3, where we surveyed some coal lands. We found this work much more pleasant than our former work as the hills in this locality have much easier slopes and the windfall which bothered us so much in the previous township was entirely absent. The hills are partly open in this township, and partly covered with large fir timber, which, being fire-killed is very hard to cut. A few cattle were being ranged on the hills, but there is an abundance of feed for many more. We finished our work in a few days, and moved up the valley of Callum creek to township 12, range 2. In accordance with your instructions, I examined the east half of this township to see how much of it would be fit for settlement, and decided that the whole eastern half would have to be subdivided. This township is rather hilly, and partly covered with large fir timber, the fir being confined mostly to the ridges, while the flat or undulating land is mostly open or covered with poplar and willow. The soil is rich, and in spite of the high

altitude, a settler in section 12 managed to raise a good crop of potatoes this year. Small creeks are very numerous, and the pasture on the hills is excellent.

This district is filling up with small ranchers who intend to run their cattle on leases during the summer, and raise feed for their winter keep on their homesteads. The cattle industry has been paralyzed by the sudden disappearance of the big ranches which ranged thousands of cattle every year, but the passing of these ranches is a matter of great satisfaction, as they invariably kept large areas lying idle for winter range, when sufficient winter feed could have been raised on a tenth of these areas had they been cultivated. The new settlers who are now locating in the hills have the right spirit, and as soon as the Government decides the lease question, there will be considerable activity again in the cattle business.

Our work in this locality was constantly interrupted by snowfalls, though the temperature remained unusually high, and the snow disappeared in a few days. Early in December I found that I would be unable to complete all the work allotted in this vicinity, and decided to cease operations as soon as my rations were exhausted. We accordingly broke camp on December 14, and moved back to section 4, township 10, range 2, where I stored the outfit for the winter. On the 16th I drove into Cowley and paid off the men. I completed my business in this locality, and left for High River and Calgary the following day, to look after some details there. I left Calgary on the 19th and reached Toronto on the 23rd.

I have the honour, to be, Sir,

Your obedient servant,

P. B. STREET, D.L.S.

APPENDIX No. 48.

ABSTRACT OF THE REPORT OF A. G. STUART, D.L.S.

RESURVEYS IN MANITOBA.

I arrived at Winnipeg on May 7, and spent the following two days in purchasing an outfit and organizing my party.

My first work for the season was the retracement of the principal meridian beginning at the international boundary. I therefore left Winnipeg on May 10, and travelled southerly over the old trail on the west side of Red river as far as Morris, and thence over well-travelled roads to Gretna.

The country through which we travelled comprises some of the oldest settled parts of the province, and is used almost exclusively for wheat growing. The roads we followed took us through thousands of the finest wheat fields, not only in the West but in the world, and we found the drive a very pleasant one.

In the vicinity west of Morris large areas of low land have recently been drained by the Provincial Government, and in this way large tracts of rich virgin soil have been rendered fit for cultivation.

Practically no homestead lands are available in the vicinity of the meridian south of Winnipeg. The lands in this district, being level or slightly rolling, and composed mostly of rich black loam underlaid with clay, command a value of from twenty-five to fifty dollars per acre. Notwithstanding this fact, each year sees the invasion of many moneyed settlers from the best farming districts of the western States to buy land in this district. Many of these are people whose parents left eastern Canada in the early days at the call of what was then the "greater west." These men, well versed in western ways and methods, are among our best immigrants.

To one accustomed to the ways of Quebec and the Maritime Provinces, the wealth and extensive harvesting methods of this older portion of Manitoba are amazing. The most modern types of farm machinery are seen on every hand, but it is very difficult to get men capable of handling and repairing these machines. The young men of the West are not going in for this kind of work, and the great need at the present time is for a class of skilled artisans and mechanical tradesmen.

After crossing the St. Francois Xavier settlement with the retracement of the meridian, we gradually left the prairie and entered a slightly rolling and more recently settled district, with scattered clumps of scrub and poplar. The settlers go in more for mixed farming, and many large and small dairy farms in the vicinity of Winnipeg supply the demands of the city markets.

A well-travelled road runs northerly close to the meridian for at least one hundred miles, and two lines of railway run northerly as far as the north boundary of township 20, both within ten miles of the meridian, making the daily Winnipeg market easily accessible for farm and dairy produce. Many range cattle are raised in this district. In the small towns along the railways there are many openings for tradesmen and business houses.

Along the meridian in the vicinity of townships 17 and 22 we passed through an extensive Galician colony. These people are fast making homes in the district despite the difficulties with which they have to contend. The country is heavily wooded with poplar, and the ground is covered with loose stone, so that in most instances it has to be cleared of both stone and wood before it is fit for cultivation. Notwithstanding these drawbacks, coupled with a lack of funds, these people are making good homes.

Their children at school are particularly bright, and the parents, through a life of industry and clean living, are developing into Canadian citizens of which the country should be proud.

The cutting and loading of cordwood, consisting of poplar, spruce and tamarack, and marketing it in the cities, gives the settlers a means of making ready money in the slack winter months. In this way, quite an extensive business has grown up along the two lines of railway. In township 19 there are surface indications of fine quarries which will, no doubt, at some later date be developed.

Along the meridian from the source of Icelandic river, in township 22, to the northeast corner of township 28, where my retracement operations ended on September 28, the line continually crosses large and small hay sloughs, which make stock-raising easy and profitable through this district.

A railway is at present under construction as far as Fisher river, and there is still much land open for homesteading which, when cleared of the timber and surface stones, will make first-class mixed-farming land.

Game in this district is fairly plentiful, moose, jumping deer, bears, partridges, prairie chickens and muskrats being found.

There are large areas of excellent grazing land, the hay needing only to be cut and stacked for winter. In lake Winnipeg, near by, large quantities of fish, including whitefish, sturgeon, pickerel, etc., are annually netted for domestic use and for market. Fuel and the best of building material can be obtained practically at one's door.

Notwithstanding these advantages, a homestead, although requiring the investment of only a trifling entry fee, has its conditions not governed by dollars and cents. It requires, as its owner, a man used to hard labour, and when the city clerk, tired of life and with a moving-picture idea of wheat fields and ranching, attempts it, he usually fails. Nevertheless, it is one of the best opportunities in the West to-day.

In the retracement of the meridian we touched on the borders of Indian reserves Nos. 16 and 44. In these reserves the land is good, and to the north, west and east the hunting is excellent. Here moose, elk and caribou are to be found in abundance.

Having finished the retracement of the meridian, the party moved southerly a distance of over sixty miles down the old Oak Point trail to resurvey township 21, range 4, west of the principal meridian. This township is occupied principally by settlers from the peasant districts of old France. These people are engaged principally in mixed farming, and, although commencing in a small way, they are working with an industry and perseverance which will make homes in the near future. The crops in this district, though small in extent, were harvested early, and all were making preparations to cultivate an increased acreage during the coming year.

On November 8 this work was completed, and I drove westerly, striking the old Fairford mail trail at Moosehorn bay, on the east shore of lake Winnipeg. I proceeded to Lower Fairford, where I crossed the river and camped about six miles north between the north limits of Indian reservations Nos. 48 and 50, where my instructions called for the survey of about five miles of road, and the resurvey and tying in of several section lines to these reserve boundaries in townships 31, ranges 8 and 9, west of the principal meridian.

The country immediately north of this work is thickly wooded with poplar. The land, generally speaking, is level, and averages four to six inches of black loam with clay loam subsoil. The extensive grazing lands and hay meadows bordering lake St. Martin make this pre-eminently a stock-raising country. Many excellent homesteads are still available. During the winter months fishing is the main industry, the Indians and the half-breeds making from fifty to two hundred dollars per month on an initial investment of a few nets and a dog train for hauling the fish to the warehouses of the several trading stations along the line of railway.

These reserves are also rich in natural resources. Here, however, the manufacture of many thousands of pairs of moccasins has made the moose and elk much

Photo by C H. Taggart, D.L.S.
Grand Prairie District in Tp. 13 R. 16, West of the Sixth Meridian.

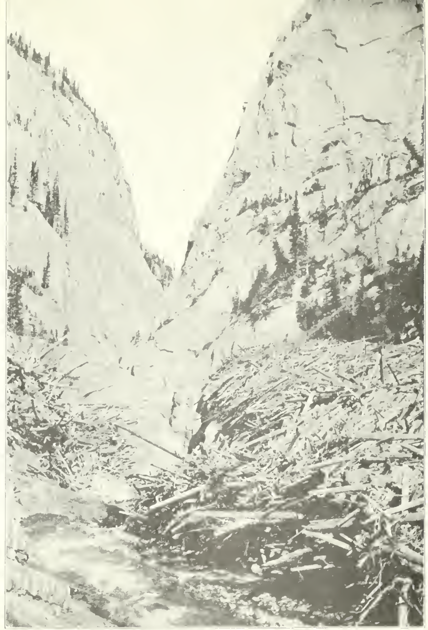


Photo by H. Matheson, D.L.S
Fiddle Creek Canyon from the South, Looking down stream.

scarcer, in the immediate neighbourhood, than in former years. For the settlers who do not wish to fish during the winter, the cordwood industry and the quarries of the Manitoba Gypsum company give ready employment.

It is most gratifying to note the change for the better coming over the Indians on these reserves. Each family has its house, garden and oxen or horses, and from 6 to 30 head of range cattle. The younger people nearly all read, write and speak both English and an Indian dialect, and often German or French, being excellent linguists. They are also all fond of music. The men all work from four to six months each year, for the trading companies, or are engaged in fishing or on railway location and construction.

This work was completed on November 25, just as the river was fit for crossing. My party was at once discharged and the outfit stored for winter, and with my assistant I proceeded by rail to Eriksdale to retraverse Swan lake, in townships 21, ranges 5 and 6, west of the principal meridian. There is substantial evidence that the water of this lake, which has no visible outlet, has lowered at least six feet during the past twenty years. In the vicinity the homesteads have all been taken up and the settlers are making remarkable progress in mixed farming, with Winnipieg as a market. The land is excellent, and wild hay plentiful. Here again the cordwood industry is in evidence during the winter.

The traverse of the main lake was completed about December 21, and I returned to Winnipeg to prepare office returns for a couple of weeks before joining Mr. Rolfson as assistant on northern surveys.

APPENDIX No. 49.

REPORT OF C. H. TAGGART, D.L.S.

SURVEYS IN THE KAMLOOPS DISTRICT OF THE RAILWAY BELT, B.C.

OTTAWA, ONT., February 26, 1913.

E. DEVILLE, LL.D.,
Surveyor General,
Ottawa, Canada.

SIR,—I have the honour to submit the following general report of my survey operations in the Kamloops district, in the railway belt, British Columbia, for the season 1912.

As soon as possible after the receipt of my instructions, I left for Kamloops, the point of organization, arriving there on Sunday, April 28.

Kamloops is a flourishing town of about 5,000 inhabitants, beautifully situated at the confluence of the North and South Thompson rivers, and is termed the 'Inland capital of British Columbia.' The surrounding country is known as the 'dry belt,' owing to the small amount of precipitation. Its elevation is 1,160 feet above sea-level, and the climate is very dry and invigorating, making it a pre-eminently desirable resort, especially for those suffering from pulmonary troubles.

The city had its start around a Hudson's Bay company's post, about one hundred years ago, and during the past summer celebrated its centenary in a most fitting manner. Many demonstrations of the old days were seen, which, when compared with to-day, show the development. This place is a divisional point for the Canadian Pacific railway, and in the near future the Canadian Northern Pacific railway line will be in operation, when it is expected that besides being a divisional point for this road, large railway shops will be erected, which will be a great boon to the city. The latter company also intend building a branch line, starting from Kamloops, to penetrate the rich and fertile Okanagan valley. The survey for it was made during the past summer.

The country around Kamloops is generally mountainous, with fertile valleys. The principal crop grown is hay and grain, which is used as feed for the great numbers of cattle and horses for which the district is noted. This industry is to some extent on the decline, and many of the larger ranches are being divided into small holdings, and extensive irrigation systems installed, for the exclusive growing of fruit.

Two fine bridges cross Thompson river; the one to the west of the town gives access to the country west of North Thompson river, and the one to the east joins the city to roads leading into the country east of the river.

The organization of my party was completed on the night of April 30, and on the morning of May 1, I left Kamloops for my first work, the subdivision of the unsurveyed portion of township 21, range 17, west of the sixth meridian, lying east of North Thompson river, and north and adjacent to the Kamloops Indian reserve.

Leaving Kamloops by the new east-end bridge, we entered the reservation for the Kamloops Indians. This large reserve, which extends easterly along South Thompson river for seven or eight miles and northerly along North Thompson river for the same distance, contains a large area of the best agricultural land in the district. Unlike many patches of good land which are of little value, this area has, in Paul creek, an abundance of good water available for irrigation purposes. The striking feature is that very little of the water or the land is being made any use of

by the Indians, whereas if the same were in the hands of thrifty ranchers great crops would be raised. Here also is to be found some fine grazing land.

The Government wagon and automobile road crosses the Indian reserve boundary into township 21, range 17, close to the river bank, whence it follows the foot of the hills. Between the river and the road is to be seen the new grade of the Canadian Northern Pacific railway, and bordering this are some fine ranches. The first of these is the Longburn ranch, owned by W. R. Austin. This ranch is of considerable size and produces fine crops of hay, grain and fruit.

The greater part of the land subdivided in this township is about fifteen hundred feet above Thompson river. The lands comprising the southwest quarter of section 36, the north half of section 26, the north half and the southwest quarter of section 27, and the southeast quarter of section 28, lie on the lower slope of the rise which forms the remainder of this township. This land is best suited for irrigation purposes in connection with some of the large ranches lying along North Thompson river. The water if brought down from Heffley lakes in township 22, range 16, could be kept well up on the slope at sufficient elevation for distribution over any of the lands on the east side of the river in sections 33, 28, 21 and 20 of township 21, range 17.

The remainder of the land is mostly open, or openly timbered, and has previously been used as range land, for which it is well suited. If sufficient water for irrigation were procurable, some portions of this land would be productive of good crops, but this essential is lacking. However, it is quite possible that the dry farming method would be successful.

In travelling along the road to our next work, in township 22, range 17, the first place of interest was the Anderson ranch, which is a very extensive one producing fine crops of hay, grain, vegetables and small fruit, and raising many head of cattle and horses. I understand that on both the Longburn and Anderson ranches extensive plans are being made for irrigation systems to bring water from Heffley lakes.

Next we passed the Edwards ranch, belonging to Mr. W. R. Austin. The chief product of this ranch is hay and grain, of which excellent crops were seen; vegetables and small fruits are also grown. The ranch is very large and extends to Heffley creek, the waters of which are carried by a system of good ditches and distributed over the land. On this ranch, near the confluence of Heffley creek and North Thompson river, and along the wagon road is to be found a first-class general store, post-office, hall, church and temperance hotel, all the property of Mr. Austin. Here our second camp was erected.

Last October, at Heffley Creek village a fall fair was held in which great interest was manifested. Products of the lands on North Thompson river and its tributaries were exhibited, and an excellent showing was made, which demonstrates the great possibilities of the district.

The land surveyed in this township is mostly rough and rolling and is timbered with fir and pine. In years past cattle have ranged over it, for which purpose it is best adapted. There are some small patches of land which, with irrigation, would be quite productive of hay, grain and perhaps small fruit. Irrigation might be possible by the construction of a long ditch leading from Heffley creek two or three miles farther up stream, but this is impracticable, as the cost would be too great for the amount of land to be watered.

North Thompson river flows through one of the principal valleys of the district, and extends for 200 miles northward, having extensive fertile areas along its banks for a considerable distance, and at present a good wagon and automobile road traverses it. In the near future, however, the Canadian Northern Pacific railway, which is now being rapidly rushed to completion, will be in operation, and will do much to develop the large country it passes through.

Our next work took us along Heffley creek to its source, the Heffley lakes, where subdivision of lands suitable for agriculture in township 22, range 16, was made.

These lands are at a considerable elevation, but judging from the excellent showing of the other ranches along Heffley and Edwards creeks, good crops of hay should be possible. In sections 9 and 22 splendid crops of hay and grain were seen, while vegetables of high order are grown. Some good range land is also to be found.

Heffley creek is a stream from fifteen to twenty-five feet in width and from six inches to two feet deep. It takes its rise in a lake of the same name, at an elevation of about 3,300 feet, and in its descent to North Thompson river falls at the rate of about 200 feet to the mile. It has a maximum flow of about 100 second-feet. Heffley lake is about two miles in length and several hundred yards wide. It affords an excellent storage reservoir for the freshet waters. The water users have co-operated in building a small dam at the lake outlet, but this is quite inadequate; the storage capacity of the lake could be greatly increased, and no water need be wasted. I made some rough measurements, and from these it appears that the lake water could be raised from two and a half to three feet above the present dam without seriously affecting any other interests. It is probable that on the upper reaches of the creek and at Heffley lake the precipitation is about twenty-five inches. The rainfall at the mouth is between eight and twelve inches, with a very light snowfall.

Heffley creek, like most of the streams in the dry belt, is vastly over recorded, but at the same time, with judicious handling there is enough water for all users. The storage, as has been pointed out, is not at its highest efficiency, and the methods used by most of the irrigators are very primitive. Much water is lost through seepage, and this could be obviated by individual irrigation works.

The most tedious and arduous piece of work of the season was the delimitation of the boundary of the railway belt across townships 23 and 24, range 15, and township 24, range 14. In most places this boundary runs over rough mountainous country, thickly wooded, and in some places the ground was covered with a thick layer of windfall. This is bad at any time, but at the time of survey, when much rain fell, it was very slippery which made the travelling extra difficult.

Crossing the summit of the high range of mountains from Edwards creek and Kenuff lake valley, a steep descent leads down to the Louis creek valley about twenty-two hundred feet below. This valley is of an average width of about three-quarters of a mile, and in it some fine bottom land is to be found along Louis creek, with some good benches lying nearer the mountains. Nearly all this land has been taken up, and good crops of hay, grain and small fruit are raised. The raising of fruit has not as yet been gone into to any extent, but from the results of some of the small patches seen it is evident that the growing of the small varieties would be very successful. A great drawback to the rapid development of the fruit-growing industry is the distance from any market. The ranchers, here, therefore, produce such crops as can be fed to cattle, sheep, etc.

The main tributaries to Louis creek are McGillivray and Cahilty creeks. On McGillivray creek a small saw-mill is in operation, the water of the creek being used for power. It is possible that a much larger power could be developed.

Cahilty creek, the main tributary of Louis creek, is a torrential mountain stream rising in the highest hills of the Louis creek drainage area, and discharging into Louis creek at an elevation of about 2,000 feet; its waters are used during the summer months for irrigation purposes. The supply is more than enough for all possible users, its maximum flow being about 400 second-feet. The water could be used to good advantage for power. Cahilty lake, about six miles from the mouth, affords excellent storage for the spring freshet. A narrow canyon through which the creek flows at the outlet of the lake could easily be dammed and a mean flow of from 25 to 35 second-feet procured.

I am indebted to the Hydrographic Survey department, under the supervision of Mr. P. A. Carson, D.L.S., for the information regarding flow and record of Heffley and Cahilty creeks.

In conjunction with the survey of the limit of the railway belt, all lands suitable for settlement in the valleys of Fadear and Cicero creeks, in township 24, range 15, and townships 23 and 24, range 14, were surveyed.

The completion of the survey of the belt limit brought us down to the Adams lake valley, about three and a half miles from the landing on Agate bay. Lying along Pass creek some good agricultural land is to be found. Squatters are located on most of it, but they cannot get entry, owing to the fact that all the unoccupied land within the railway belt in this valley is a timber berth. In this valley, in section 1, township 25, range 14, a small survey was made to tie in the Homestake group of mineral claims. These claims are not in operation, for the reason that the copper ore is not of sufficiently high quality to warrant the excessive cost of transportation to the railway.

A good wagon road has recently been constructed, branching off the Louis creek road at Blucher Hall post-office, and after following the Adams lake valley, terminates at the landing on Agate bay. Good crops of hay and grain were seen, and the yield of potatoes, etc., was fine.

Our next work was in what is known as the Back valley, township 20, range 15, and to reach it we were obliged to return to Kamloops, where we arrived at noon on October 23. After stocking up with supplies and getting the outfit in condition for winter weather, we left Kamloops at noon on the following day, taking the wagon road following South Thompson river for five or six miles to where it branches, leading into the Harper ranch. This is an old and extensive ranch, and is considered one of the best in the district. The land is very productive of hay, grain and vegetables, and a considerable amount of fruit of good quality was seen. At one time as many as three thousand head of cattle were handled on this ranch, but to-day from nine hundred to one thousand is the greatest number that can be successfully cared for, owing to the fact that the range land is being more and more cut off as the country is settled, and is not as productive of bunch grass, owing to many years of grazing, and also during the past few years the winter seasons have been more severe and the snowfall greater, necessitating the feeding of the stock for a much longer period. An average of about one ton of fodder per head is required to winter stock successfully. In the winter of 1911-12 feeding had to be started in November, whereas in an ordinary year previously, feeding was seldom started before January 1, and sometimes not before the 15th.

These statements may also be applied to the whole district.

From the Harper ranch to Pinantan lake the road rises rapidly and crosses the high range of hills forming the north limit of the South Thompson valley. On the north shore of Pinantan lake the first ranch in the Back valley is seen, and following this lake easterly, and along Paul creek, numerous ranches are located. Good crops of hay and grain were seen, for the maturing of which no irrigation was used.

A much better route for reaching this valley is now available. A new wagon road which has been completed this winter branches off the North river road at the crossing of Paul creek, and following the creek passes close to Paul lake and enters township 20, range 15 in section 31. The road then follows along the creek from the lake to near the west end of Pinantan lake, where it connects with the old road. This route is preferable, as there are no steep grades like those on the old road.

The work in this township consisted in the establishment of the north boundary of the township as far as the northeast corner of section 31, and running the meridional section lines to monuments established by previous surveys. The lands surveyed are mostly high and rolling, openly timbered with fir and pine, and a thick growth of underbrush. They cannot be said to be farming lands, although some small patches of good land are to be found. The district is best suited for ranching. North of the north boundary of this township is the Niskonlith forest reserve.

Having completed the survey in township 20, range 15, we moved camp to Trapp lake, township 17, range 17, where we arrived on November 9, and proceeded to subdivide a tract of range land in the eastern portion of the township. We also traversed

Trapp lake, and resurveyed fishing stations numbers two and three for the Kamloops Indians. The land subdivided is mostly open and rolling, and ordinarily is not productive of any kind of crop, owing to the lack of water. In my report of 1911 can be found a detailed report of this valley.

Having completed work in this township on November 20, we moved to township 18, range 18, where a portion of the township lying east of the Long Lake forest reserve was subdivided. This was completed on December 15, and on the following day we again arrived in Kamloops, where we took train for Chase, a small thriving town, situated on the Canadian Pacific railway, at the outlet of Little Shuswap lake in township 21, range 13, west of the sixth meridian.

This town possesses a large saw-mill, fitted with the most modern machinery, and operated by the Adams River Lumber Co., and on all sides can be seen the results of a progressive lumber industry. There is also a splendidly-appointed hotel which is not surpassed in towns many times the size of this one. During the summer months many tourists and commercial men make it a point to arrive in Chase to spend Sunday. Boating and excellent fishing are to be had on the lake.

My instructions called for the establishment of the east boundaries of section 25 and the south half of section 36, and the north boundary of section 25. This work proved to be difficult, owing to the fact that the lines ran over a very steep rocky mountain, which was blanketed with snow several inches deep, making it slippery and dangerous.

Having completed this piece of work I decided to suspend operations owing to the lateness of the season and the coming of severe weather. I accordingly returned to Kamloops on Saturday, December 21, paid off the party, and on the 23rd stored the outfit for the winter. On the 26th, having closed up all business in connection with the season's operations, I left for Ottawa, where I arrived on December 31.

The weather conditions throughout the season were much out of the ordinary, and most unfavourable for survey oper tions owing to excessive rains during the months of June, July, August and September. No real warm weather was experienced. At the outset of the season things looked very bright for the farmer, especially those who are not so fortunate as to have plenty of water for irrigation. Good crops could easily be raised on any of the land, which in an ordinary year would be baked and cracked from lack of water and from the extreme warm weather, making growth impossible. When the crops of hay and grain, which were excellent throughout the district, were ready for harvest and the rains continued, great disappointment was felt, and tons of hay and grain were ruined before it was got into the stack.

In speaking with one man, who has been ranching in the district for the past forty years, he said:—

> 'Had any one asked me some years ago if we would ever receive too much rain in the dry belt, I would have said, emphatically, "No," but I will admit I would have been wrong, for this year we have had far too much. If in every year we were to receive but half the amount that fell this summer, all the bottom and bench lands would produce good crops, and without irrigation. I have put in a crop on my ranch annually for the past thirty-seven years, and have never seen as much rain. The climate is certainly changing.'

Two heavy cloud bursts were experienced during the summer, and many heavy thunderstorms. During one of these, which occurred after all hands had rolled in for the night, we were awakened by the falling of a thirty-inch fir tree, which fell parallel to three tents in which five men were asleep; had it come but ten feet to the right all five certainly would have been killed.

I have the honour, to be, Sir,

Your obedient servant,

C. H. TAGGART, D.L.S.

APPENDIX No. 50.

ABSTRACT OF THE REPORT OF C. M. WALKER, D.L.S.,

MISCELLANEOUS SURVEYS IN SOUTHERN ALBERTA.

According to instructions, I procured my outfit at Calgary and, having shipped it to Medicine Hat, I took the trail there leading to township 2, range 6, west of the fourth meridian where my first work lay.

During the summer and fall of 1911, this old trail running south from Medicine Hat, was surveyed and graded to some extent, an effort being made to follow the regular road allowance where at all possible. Naturally, many steep grades resulted, so that in wet weather the present road is almost impassable with any load. At the present time this is somewhat of a hardship for the settlers to the south, many of whom are compelled to haul their grain, produce and supplies over this road for sixty or seventy miles. However, when grading is completed and culverts and bridges put into proper shape, a fairly good and direct highway will result.

Arriving in township 2, we immediately proceeded with the retracement survey.

As a general thing, the mounds of the previous survey were found on the ground in a more or less obliterated condition and, in every case, were renewed, but many of the original iron posts were missing.

The greater part of this township is gently rolling prairie, quite suitable for mixed farming.. Those sections, however, adjoining Milk river, namely sections 18, 7, 8, 5, 4, the south-west quarters of sections 9 and 3 and portions of the southern half of sections 2 and 1, are of little use. Several sections in the northeastern portion of the township, namely, sections 25, 35 and 36, and the eastern half of 34, are also so much cut up by bad lands as to be of little value for farming.

Practically all of the available land in this township has been taken up either as homesteads or pre-emptions.

During June of 1912 the crops appeared to be in splendid condition and gave promise of an abundant harvest. In the preceding two years, however, the crops were failures, due to drought and early frosts.

Large areas of land were under cultivation in this district, this season, the different grains being wheat, oats and flax. Of these three, flax appears to be the best adapted to local conditions.

The climate is not at all suitable for corn, even as green feed, but, on the other hand, small vegetables of an exceptionally good quality and of considerable variety are grown. Potatoes especially do exceedingly well. At present, on account of the long haul to market, small vegetables are raised purely for home consumption, but in the event of a railroad being constructed through the immediate neighbourhood, and several are proposed at present, market gardening should prove to be a very lucrative business.

The homesteaders in township 2 are principally Swedish Americans, many of them having proved up, and advantageously sold their homesteads in the western States before coming to this country. Consequently the buildings in the neighbourhood are of a somewhat better class than is usually found on the average homestead.

Mixed farming is carried on to some extent, the stock being of medium quality; all the range land being taken up under lease, the amount of stock for the individual settler is limited to his own homestead and pre-emption.

A post-office, on section 10, and a school on section 15, have been opened up recently and prove great conveniences to the homesteaders of the township.

The soil is a good variety of clay to clay loam, though in the near vicinity of Milk river valley much sandy loam and sandstone rock appear on or near the surface.

Sloughs are to be found in different parts of the township, which provide water and a fair amount of slough grass for stock. A number of the settlers have obtained good and abundant supplies of water by sinking wells from fifty to sixty feet, while others use water from surface wells placed in the vicinity of sloughs.

Very little alkali is in evidence anywhere in the township, with the exception of the bad lands previously referred to.

Township 1, range 6, is of a similar nature to township 3. It is of a gently rolling nature, the exception being that portion included in the Milk river canyon, which cuts off most of the northeastern part of the township.

The soil in this township is not of so good a quality as that of township 2, being of a harder nature, with considerable alkali in evidence.

The whole township is under lease as range land, which is the only thing it is suitable for, and consequently no settlements of any kind have been made therein.

In addition to Milk river, which traverses township 1, a small stream known as Kennedy creek is to be found flowing southeast from the central portion of the township. By allowing the water from this creek, which is more or less alkaline, to seep through into wells placed near at hand, drinking water is obtained.

The township affords a fair range for stock, with a constant water supply in Milk river and Kennedy creek. It appears, however, to be suited for no other purpose.

Though Milk river itself at this point is an insignificant stream, its valley attains huge proportions. The river flows sluggishly along the bottom of a valley, some four hundred feet below the prairie level, and varies from fifty to two hundred feet in width, ordinarily. On the other hand, the sides of the valley are from one to four miles apart. These sides are composed chiefly of bare clay banks with, here and there, projections of sandstone. Huge clay buttes are much in evidence, along the valley, often running up to the prairie level, then dipping down to the level of the river again. These bad lands extend from one to two miles back from the river on either side, thus rendering a considerable portion of the country useless.

Along Milk river valley, a considerable quantity of cottonwood is to be found, both large and small. The latter provides for fence posts, &c., needed by the settlers. The larger trees are of no value, since the labour of getting them out of the valley is excessive, packing being the only available method.

Along the sides of the valley, many seams of coal are to be seen. These seams appear to lie in planes parallel to the prairie level and extend along the sides of the valley for miles. The layers vary in thickness from three to ten feet and, when the outside surface has been removed, the result is a fair sample of lignitic coal, which makes a hot fire and leaves little shale, though much ash. This coal proves to be a convenient and cheap fuel for the needy homesteader.

Having completed the required surveys in townships 2 and 1, range 6, we drove back to Medicine Hat and shipped our outfit to Banff, where our next work lay.

Our first work there consisted in locating a cemetery and in running traverses for the determination of other land suitable for the extension of the town plot, to the south and east.

An investigation survey was then made to ascertain what surveys had really been made in the villa lot section, years ago. As a number of buildings had been erected in this section, they had to be located on the ground. Traverses of all the roads in this part of the town, along which buildings or improvements were found, were made and portions of those ranges in which improvements were found were then posted, by means of information obtained from these traverses.

Intermittently with this work, we were engaged on a retracement survey of the Banff town plot, this survey calling for the posting of all corners of all lots in the plot.

Photo by E. Deville, D.T.S.

Columbia River at Revelstoke.

Photo by E. Deville, D.T.S.

Shuswap Lake at Sicamous.

Due to the absence of governing posts in some of the blocks, a number of buildings have been erected over the street line or over lot lines.

In the case of blocks, with curvilinear boundaries, no posts or marks were to be found on curved portions to indicate in any way that a previous survey had been made.

Additions were made to the town plot, comprising eight new blocks, namely Nos. 28, 29, 30, 31, 32, 33, 34 and 35.

Of these extension blocks, the two most desirable are Nos. 34 and 35, both of which contain some very choice lots which are very convenient to the main portion of the town.

Having completed the town plot and extensions as described, my next instructions called for a traverse and levels over all the roads and paths for a distance of six miles out of Banff.

In doing this work, the following roads and paths were traversed and levels were taken along the centre of the roads at 100-foot stations:—

Road to Sundance canyon.
Spray River road.
Loop drive.
Corkscrew drive.
Anthracite road to Anthracite and return.
Lake Minnewanka road to Vermilion Lake road.
Mountain avenue.
Sulphur Mountain bridle path to top of Sulphur mountain and observatory.
Tunnel Mountain bridle path to top.
In the case of the last two roads, vertical angles were read instead of levels.

Having completed the work for which I had instructions, I disbanded the party on December 15.

APPENDIX No. 51

REPORT OF J. N. WALLACE, D.L.S.

LEVELLING ALONG BASE AND MERIDIAN LINES IN SASKATCHEWAN AND ALBERTA.

CALGARY, ALTA., March 31, 1913.

E. DEVILLE, Esq., LL.D.,
Surveyor General,
Ottawa, Canada.

SIR,—I have the honour to submit the following report on levelling operations during the season ended March 31, 1913.

In regard to level work done along the meridian and base lines surveyed last season, considerable progress has been made not only in a large additional mileage of levels, but in improved field work, and in the methods followed in recording the level notes and arranging the results. As the system of levels is necessarily built up from the south to the north, the new lines run each year are wholly dependent for their datum on the lines which were run farther south in previous years. The base lines being the pioneer lines of the whole system of survey, their very nature necessitates that the levels taken along them, while they are being surveyed, must be dependent on themselves. In the country where these lines are being surveyed there is, in fact, practically no other feasible route for running independent lines of levels. Occasionally a line can be run over the ice of some large river in winter, and such have been already utilized. Railway lines, which are the routes universally used to run long lines of levels in settled country, do not exist where base lines are being surveyed. The railways follow comparatively far in the rear, and such has always been the case.

It is necessary, therefore that as great accuracy as the field conditions of an unsettled district will allow be aimed at in these levels along base lines, and further that, as opportunities arising from new railways or other causes occur, these should be utilized to run independent lines of precise levels which, running north and crossing former base lines, even though at widely separated points, will cancel the accumulation of errors in the base lines. By this means, while a certain considerable distance must always intervene between new base lines and the nearest precise elevation, and while from the nature of the case, these new base lines must carry a heritage of error from the intervening base lines, yet if the lines of precise levels are extended continually north, even though always in the rear, this heritage of error will not increase, but will be cut out in the southerly base lines as quickly as it increases in the northerly ones.

As may readily be understood by consideration of the circumstances, the levels run along base lines afford the very first information of elevations of the various features of the country. These levels suddenly change a condition of affairs in which elevations were wholly unknown to a condition where they are known with a high degree of accuracy. The lines of levels are themselves always run twice, each mile being run in opposite directions, and if these duplicates do not agree within 0·10 feet to a mile, the mile must be levelled over again. In practice, this limit is never exceeded, and the duplicate lines very seldom show even this discrepancy.

The additional mileage of levels run along meridians and base lines in the year ended March 31, 1913 is as follows:—

				Miles.
Along and west of the		principal meridian		597
"	"	second	"	156
"	"	third	"	156
"	"	fourth	"	282
"	"	fifth	"	156
"	"	sixth	"	144
				1,491
			Run in previous years.	2,913
			Total.	4,404

Three thousand three hundred and forty miles of this total of 4,404 miles has already been connected either to sea-level datum or to some railway datum closely approximating sea-level, while the remaining 1,064 miles have not yet been connected to any known datum. Of this unconnected mileage of levels, about 250 miles are situated in a district extending 50 to 100 miles northwest of Edson on the Grand Trunk Pacific railway, which is the nearest present railway point; about 100 miles are along three short base lines near the foot-hills of the Rocky mountains, 100 miles northwest of Calgary, and the greater part of the remainder is in the district north and west of lake Winnipeg.

The 3,340 miles of levels which have already been connected to a known datum are spread over a country extending from eastern Manitoba to western Alberta. To give some idea of the extent of the country through which they run, it may be mentioned that, using the water of lake Winnipeg for a connection of 60 miles, there exists a continuous line of levels from the intersection of the principal meridian and the international boundary, in southern Manitoba, to the extreme northwest of Peace River block, a length of 1,520 miles, every mile of which, except about 50 miles along one railway in Manitoba, has been run along some meridian or base line, and the northwesterly end of this connection is over 400 miles in advance of any railway.

The longest line of levels in one absolutely straight line occurs on the fourth meridian, along which continuous levels have been run from township 60, south of Cold lake, to township 115, on the south shore of Athabaska lake, a distance of 330 miles.

Apart from the levels along meridian and base lines, but connected with the same system, the following lines of levels were run during the past year:—

	Miles.
(1) From Athabaska Landing to the crossing of the fifth meridian, along Athabaska river	70
(2) From Edmonton to Athabaska Landing, the southerly part along the travelled highway, the northerly part along the Canadian Northern railway	95
(3) From Prince Albert to Hudson Bay Junction, along the Canadian Northern railway	162
(4) From Warman to Islay, along the Canadian Northern railway	193
(5) From Prince Albert to Warman, along the Canadian Northern railway	73

The total length of all these is 592 miles. They may be described as forming a line from Hudson Bay Junction via Prince Albert, Warman, Edmonton and Athabaska Landing to the fifth meridian where it crosses Athabaska river, except a gap of 145 miles between Islay and Edmonton.

These lines, except the first, are all run as precise lines of levels, the instruments used being a precise level of the United States Coast and Geodetic survey pattern

and precise rods graduated into yards, tenths and hundredths of yards. The graduation of the rods is practically of the same pattern as used on precise meter rods. The smallest graduation on the rod is one-hundredth of a yard, the readings being estimated to thousandths. Three wires were read, as usual, the sum giving differences of elevation in feet. The readings of the three wires at each sight were read over again if the difference between the wire intervals exceeds three-thousandths of a yard.

All lines were run independently in both a forward and backward direction. The limit which was set is expressed by the formula:—

$$0.017 \text{ feet} \times \sqrt{\text{number of miles}}$$

and unless the duplicate of a mile section agreed within this amount, the section was levelled over again.

The use of a railway handcar was allowed by the Canadian Northern railway, and one was used in all cases. The level party consisted of the leveller, recorder, two rodmen, umbrella man, cook and a man appointed by the railway to watch the handcar, and one man to make bench-marks. The party camped in tents on all the lines. Subsequent experience shows, however, that it is often more economical to board the party at the hotels if there are sufficient small towns. The reason of this is almost entirely due to the expense of a cook for a small party. A cook requires the same wages to cook for one man or a dozen, and allowing for his wages and board the cost of a cook for a party of six men practically amounts to fifty cents per man per day.

In many cases, however, there were long stretches of line with no hotel, necessitating a camp and a cook. In the case of the line from Prince Albert to Hudson Bay Junction there was no town whatever between Tisdale and the Junction, a distance of 73 miles, although there were several lumber camps which, however, were not suitable for the survey party.

The chief trouble about dispensing with a camp and cook is where gaps occur between towns which are too far apart to allow the work to be carried to the middle from each end. One or two such gaps, even though exceptional, would cause serious inconvenience without a camp.

A great trouble on some of the lines was the infrequency of trains, and the number of stopping places where there was no railway agent, and hence no means of knowing when a freight train would pass which could be utilized to move camp. Especially on the Hudson Bay Junction line freight trains were few and far between, and an experience of three months failed to discover any rule by which the arrival of a freight train could be foretold, where there was no agent.

After many efforts to solve the puzzle of the time of arrival of a freight had failed, reliance had to be placed on moving the camp outfit in the baggage car of the daily passenger train. This not only resulted in trying the conductor's temper at the delay but, as the work got farther east, the time of arrival of the train got later each move, until, near the end of the season, it was long after dark when the passenger train picked up the camp outfit, and darker still when it deposited it at some flag station with no accommodation for the party until the tents were pitched. It would be a mistake to suppose that such lines of levels have no transport difficulties.

The matter of permanent bench-marks in a district where there are no structures of stone or concrete is best arranged by establishing special ones. These were made by building a small concrete pillar. A hole about a foot and a half in diameter and 6 feet deep is dug with a crowbar and a shovel with an 8 foot handle, known as a spoon. A footing of concrete having been placed in the bottom of the hole, a hollow box made of four planks, 1 foot square at the base and 7 inches square at the top, is then placed on the footing and the box is filled with concrete. A brass plate with a shank attached is sunk in the top of the pillar and the elevation of this recorded after the pillar has been filled in and had a week or so to settle and become firm. Such

a concrete pillar is much the best kind of bench-mark in the absence of a substantial bridge or building, but the size used is somewhat small, and in the latter part of the season a larger size was made. It was frequently very difficult to get sand and gravel. During the season, 77 such pillars were made.

In addition to establishing the permanent bench-marks at every station and, in many cases midway between stations, temporary bench-marks were left at the end of every mile. These consisted of railway spikes eight inches long and half an inch square driven into telegraph poles. They were established chiefly as temporary marks for checking each day's work but, although not really stable, yet in the case of poles situated on locally high ground where there is not much moisture in the soil to cause heaving by frost, they have a decided value as a future reference, where precision is not required.

The only intermediate sights recorded were the elevations of the base of rail at each railway station, but in the future it is intended to record the elevations of all important features crossed, such as streams.

The following is a short description of each of the several lines of levels which were run:—

1. *Athabaska Landing to the fifth meridian, 70miles.*—This line was necessarily levelled in winter. It was run by Mr. de la Condamine between February 5 and March 6, 1912. The bench-marks are marks left on the various stopping-houses, easily found but not of a very permanent character. It is intended to replace them by more permanent marks. The party consisted of a leveller, two rodmen, a cook and a teamster with one team. Camp was moved with the aid of passing freighters. The line of levels was commenced at a Canadian Northern railway bench-mark at Athabaska Landing and ended on the bench-marks at the southerly end of the fifth meridian levels. These last were run in the year 1911 along this meridian from Athabaska river to Peace river, a distance of 315 miles.

The line up the river from Athabaska Landing at present forms the only connection which supplies a known datum for all levels in the Peace River district.

2. *Edmonton to Athabaska Landing, 95 miles.*—This was commenced on May 3 and ended July 23.

It follows the travelled highway for 61 miles northerly from Edmonton, and then follows the Canadian Northern railway, which at that time was constructed but not open for traffic. Owing to the rough surface of the southerly part of the route, progress was much slower than is the case where running a line of levels along a railway. Bench-marks were left at a distance of three to four miles apart. They consist of three-inch galvanized iron pipes sunk in concrete foundations four feet below the surface, the top of the cap of the pipe in each case appearing ten inches above ground and being the recorded elevation.

The probable error of the mean of a mile section, as computed from the discrepancies between the forward and backward lines of each individual section is 0.0040 feet. The total discrepancy for the whole line is 0.104 feet.

3. *Prince Albert to Hudson Bay Junction, 162 miles.*—This line was commenced on August 2 and completed on October 17. Between Prince Albert and Tisdale the Canadian Northern railway, over which the line of levels was run, passes through a partly open country. From Tisdale to the end of the line the country is thickly timbered, affording shelter from wind, a very important consideration. The line of levels was run by Mr. de la Condamine from Prince Albert to Star City (76 miles), which he reached on September 6. On that date he left camp to measure a precise base line with the invar apparatus at Salmon Arm, B.C. This base, which is 5.1 miles long, was measured in connection with the triangulation of the railway belt, and occupied Mr. de la Condamine till the end of the season. When he left I continued the line of levels for the remaining 86 miles to Hudson Bay Junction, reaching there on October 17.

Permanent bench-marks, consisting of concrete pillars, have been established close to every station named in the railway time table, whether the district is settled or not and, in addition, many such pillars have been placed midway between stations, and frequent marks have been left on trestle bridges.

This line of levels shows the smallest probable error, for a mile section, of any line run this past season, being 0.0030 feet for the 86 miles I levelled, and 0.0033 feet for the 76 miles levelled by Mr. de la Condamine. The time taken was 76 days from the day of commencement to the day of ending. This is at the rate of 64 miles per month. The average run of a fair day was seven to eight miles of single line. Conditions of transport caused a good deal of delay. On the other hand, few days were lost owing to high winds, as the line was sheltered. In the whole 162 miles I had to re-run only 4 miles, and Mr. de la Condamine only six miles. In nearly every one of these miles the limit of 0.017 feet was largely, exceeded, and was due to some obvious unfavourable cause which would have had practically as great an effect whatever the speed. The discrepancy for a mile exceeded 0.010 feet in only 26 per cent of the whole mileage.

It has been stated by more than one level organization that a small percentage of re-running indicates excessive care and slowness, and that the speed should be such that ten per cent of the line should require to be re-run. In other words that if a certain limit of error is set, it should be exceeded in one mile in ten in order to adjust the speed to the extreme limit. I do not follow the reasoning which instructs a leveller not to admit miles having a discrepancy greater than a certain limit into his final returns and yet instructs him to go so fast that he should exceed this limit occasionally. With a limit so high as 0.017 feet x $\sqrt{}$ number of miles between bench marks, say four miles apart or a total of 0.034 feet, it seems that a speed deliberately set to exceed this limit would be such as to cause detriment to the precision. The discrepancy found is not, by any means, in itself a guarantee that the apparent precision is really attained, if the speed is set beyond the extreme limit of the observer's skill. At the end of his season he has admittedly gone beyond the limit of his skill in ten per cent of the work, and the fact that such results are cut out of the final line appears somewhat like a method of rejecting certain observations in order to reduce the final probable error.

Whatever may be said in favour of instructing a leveller that he should deliberately go so fast as to exceed the limit allowed in ten per cent of the mileage, it is an instruction which does not appear in many of the best level organizations.

Warman to Islay, 193 miles; and Prince Albert to Warman, 73 miles.—These two lines were run by Mr. L.O.R. Dozois, D.L.S. The first was commenced at Warman on June 5, 1912, and ended on September 24. Mr. Dozois then proceeded to Prince Albert and levelled southerly to Warman, where he ended the season's work on October 26. The running of this last line closed a gap in the levels, and formed a continuous line of levels from Hudson Bay Junction to Islay, 428 miles in all.

Along the line west of Warman, bench-marks were placed one at each station and one midway between stations for the first few stations, after which the midway bench-mark was omitted owing to the difficulty of transport of cement, gravel and tools, and, as a compromise, two bench-marks were established near every station. The stations average seven to eight miles apart, and the two bench-marks are placed one about a quarter of a mile east of the station, and the second about the same distance west of the station. The bench-marks consist of concrete pillars in the great majority of cases.

On the line from Prince Albert to Warman the bench-marks are, as a rule, on buildings.

Considerable trouble was caused, especially on the Warman to Islay line, by frequent high winds, the lines being generally over almost open prairie. From Warman to Bresaylor this line gives good results, but west of Bresaylor a marked

negative discrepancy began to accumulate. This was probably, in a large measure, due to the track being re-ballasted west of Bresaylor. This may have given rise to a persistent settling of the turning points on the rail as the car passed over them in moving forward from one instrument station to another. There undoubtedly might be a tendency this way, but under similar circumstances when running the line of levels from Edmonton to Athabaska Landing, no persistent systematic error was shown to be brought about by this cause, although the track was an entirely new one, and only ballasted with sand a few days previous to the running of the line of levels.

Whatever the cause, the discrepancy is negative almost continuously west of Bresaylor, although the individual intervals between bench-marks, except in a very few instances, are all within the specified limit.

The probable error of the mean of a mile section is 0.0039 feet.

The line of levels from Prince Albert to Warman was run under more favourable conditions as regards absence of wind. The probable error of the mean of a mile section is 0.037 feet. The total accumulated discrepancy for 73 miles is 0.134 feet. This line was run more speedily than any other line, the whole distance, including a day's work in connection at each end, being done in 31 days, between September 26 and Octotber 26.

I have the honour, to be, Sir,
Your obedient servant,

J. N. WALLACE, D.L.S.

APPENDIX No. 52.

MAGNETIC OBSERVATIONS.

This appendix contains the results of magnetic declination observations received during the year ended March 31, 1913.

Each observed declination has been reduced to the mean of the month in which the observation was taken by means of the continuous observations at the magnetic observatory at Agincourt.

A table is also given of the results of the observations for the determination of magnetic dip and total intensity taken in the years 1908 and 1910.

MAGNETIC DECLINATION.

Place.	Tp.	Rge.	Mer.	Date.		Declination.		Observer.
40·00 N.—SE. cor. sec. 16	18	1	E.Pr.	May	29	12	34·3	C. F. Aylsworth
40·00 N.— " 16	18	1	"	June	3	12	31·6	"
50·00 E.—NE. " 9	18	1	"	"	5	12	34·7	"
40·00 N.—SE. " 16	18	1	"	May	28	12	25·9	"
At NE. cor. sec. 3	16	6	"	July	1	12	46·2	"
7·00 S.—NE. cor. sec. 25	25	6	"	Aug.	12	11	58·3	"
21·00 N.—NE. " 24	25	6	"	"	12	11	56·9	"
At NE. cor. sec. 4	25	6	"	"	27	11	25·5	"
13·00 E.—NE. cor. sec. 3	25	6	"	"	29	11	33·2	"
At NE. cor. sec. 9	25	9	"	"	26	11	35·1	"
" 11	16	11	"	July	1	13	04·0	"
38·00 S.—NE. cor. sec. 35	10	13	"	Nov.	22	10	55·9	W. J. Deans.
25·00 S.—NE. " 35	10	13	"	"	23	12	48·0	"
57·00 W.—SE. " 1	11	13	"	"	25	10	34·6	"
57·00 W.—SE. " 1	11	13	"	"	25	10	34·6	"
72·00 W.—NE. " 33	10	14	"	Oct.	14	10	57·4	"
40·00 W.—NE. " 32	10	14	"	"	15	10	57·1	"
55·00 E.—NW. " 13	10	14	"	"	17	9	55·8	"
55·00 W.—SE. " 3	11	14	"	"	19	12	41·7	"
45·00 W.—SE. " 6	11	14	"	"	21	10	51·4	"
15·00 S.—NE. " 23	11	14	"	"	24	10	43·8	"
At NE. cor. sec. 35	11	14	"	"	18	11	46·5	"
5·00 N.—NE. cor. sec. 36	11	14	"	Nov.	19	11	14·0	"
10·00 S.—NE. " 32	10	15	"	"	5	10	44·2	"
55·00 S.—NE. " 18	11	15	"	Oct.	25	10	52·1	"
48·00 S.—NE. " 5	12	15	"	Nov.	18	10	36·1	"
At NE. cor. sec. 25	7	16	"	Sept.	4	8	02·2	"
" "	7	16	"	"	7	8	23·5	"
70·00 S.—¼ post N. by sec. 24	7	16	"	"	11	8	34·0	"
48·00 S.— " " 36	7	16	"	"	12	7	45·1	"
37·00 N.—SE. cor. sec. 1	8	16	"	"	16	8	16·5	"
59·00 S.—¼ post N. by sec. 1	8	16	"	"	18	7	25·9	"
25·00 W.—NE. cor. sec. 30	7	17	"	"	2	8	26·1	"
At NE. cor. sec. 30	7	17	"	"	9	8	46·0	"
6·00 N.—NE. cor. sec. 24	9	17	"	"	15	8	36·0	G. A. Bennett.
16·00 N.— " 1	9	17	"	"	18	9	25·3	"
38·11 N.— " 25	9	17	"	"	27	8	57·2	"
49·00 N.— " 25	9	17	"	"	27	8	57·1	"
49·00 N.— " 25	9	17	"	"	27	9	06·8	"
25·5 N.— " 1	10	17	"	Oct.	7	9	28·2	"
25·5 N.— " 1	10	17	"	"	8	8	43·9	"
11·00 S.— " 36	10	17	"	"	12	11	09·5	"
57·00 N.— " 13	10	17	"	"	13	9	06·5	"
25·50 N.— " 1	10	17	"	"	14	8	38·5	"
57·00 N.— " 13	10	17	"	"	14	9	06·9	"
57·00 N.— " 13	10	17	"	"	14	9	08·2	"
At NE. cor. sec. 12	1	1	Pr.	May	19	12	16·4	A. G. Stuart.

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
At NE. cor. sec. 12	1	1	Pr.	May 19	12 14·0	A. G. Stuart.
" " 13	2	1	"	" 20	12 06·2	"
" " 13	2	1	"	" 20	12 14·2	"
40·00 N.—NE. cor. sec. 24	3	1	"	" 24	13 15·2	"
At NE. cor. sec. 25 (trial line)	5	1	"	" 29	13 02·4	"
" " 25 "	5	1	"	" 29	13 15·8	"
Centre E. by sec. 36 "	6	1	"	June 3	12 21·0	"
" " 36 "	6	1	"	" 3	12 20·9	"
" " 24 "	7	1	"	" 5	13 11·6	"
" " 24 "	7	1	"	" 5	13 09·7	"
" " 36 "	8	1	"	" 7	13 49·5	"
" " 25	9	1	"	" 11	13 55·6	"
" " 25	9	1	"	" 11	13 51·2	"
" " 1	10	1	"	" 12	13 54·4	"
" " 1	10	1	"	" 12	13 55·0	"
" " 24 (trial line)	11	1	"	" 19	13 55·3	"
" " 24 "	11	1	"	" 19	13 54·6	"
" " 13	13	1	"	" 26	13 23·3	"
At NE. cor. sec. 13 (trial line)	13	1	"	" 27	13 34·9	"
" " 24 "	14	1	"	July 4	13 37·5	"
40·00 N.—NE. cor. sec. 1	15	1	"	" 6	13 34·9	"
At ¼ post E. by sec. 13	15	1	"	" 9	14 03·1	"
Centre E. by sec. 1	16	1	"	" 10	13 10·3	"
" " 1	16	1	"	" 10	13 12·8	"
At NE. cor. sec. 24	17	1	"	" 22	13 26·2	"
" " 13	17	1	"	" 23	12 57·1	"
10·00 N.—NE. cor. sec. 36	17	1	"	" 25	12 38·8	"
10·00 N.— " 36	17	1	"	" 25	12 37·7	"
At NE. cor. sec. 36	19	1	"	Aug. 3	12 42·2	"
38·00 chs. on E. by sec. 13	20	1	"	" 6	12 44·4	"
20·00 N.—NE. cor. sec. 25	20	1	"	" 9	13 13·6	"
" " 25	20	1	"	" 9	13 16·3	"
1·87 N.— " 13	21	1	"	" 18	13 21·1	"
" " 13	21	1	"	" 18	13 19·1	"
At NE. cor. sec. 24	22	1	"	" 22	13 33·0	"
" " 25	22	1	"	" 24	13 41·5	"
At ¼ post on E. by sec. 36	23	1	"	" 30	13 26·5	"
" " 36	23	1	"	" 30	13 27·8	"
60·00 N.—NE. cor. sec. 12	24	1	"	Sept. 2	13 06·2	"
" " 12	24	1	"	" 2	13 05·8	"
30·00 N.— " 12	25	1	"	" 7	13 14·9	"
At NE. cor. sec. 13	26	1	"	" 18	13 09·2	"
" " 13	26	1	"	" 18	13 07·7	"
" " 36	27	1	"	" 24	12 43·5	"
" " 36	27	1	"	" 24	12 49·3	"
Centre E. by sec. 24	28	1	"	" 27	12 26·0	"
" " 24	28	1	"	" 27	12 24·3	"
" " 24	28	1	"	" 27	12 26·2	"
21·60 W.—NE. cor. sec. 31	60	1	"	Nov. 13	14 24·7	O. Rolfson.
" " 31	60	1	"	" 13	14 19·4	"
" " 31	60	1	"	" 13	14 24·1	"
" " 31	60	1	"	" 13	14 24·4	"
" " 31	60	1	"	" 13	14 25·4	"
" " 31	60	1	"	" 14	13 47·7	"
" " 31	60	1	"	" 14	14 37·6	"
" " 31	60	1	"	" 14	14 21·1	"
" " 31	60	1	"	" 14	14 22·1	"
" " 31	60	1	"	" 14	14 04·1	"
32·50 W.— " 32	60	1	"	Oct. 25	14 37·2	"
59·42 W.— " 32	60	1	"	" 29	14 08·0	"
21·66 W.— " 31	60	1	"	Nov. 13	14 29·9	"
" " 31	60	1	"	" 13	14 26·5	"
" " 31	60	1	"	" 13	14 23·3	"
12·79 N.— " 12	61	1	"	June 14	14 18·7	G. H. Herriot.
39·25 N.— " 24	61	1	"	" 19	13 35·6	"
16·53 N.— " 24	62	1	"	" 28	14 06·5	"
30·68 N.— " 24	63	1	"	July 10	13 42·9	"
59·75 W.— " 32	64	1	"	Aug. 15	12 28·7	O. Rolfson.
4·55 N.— " 24	66	1	"	" 7	13 58·6	G. H. Herriot.
76·82 N.— " 13	67	1	"	" 14	11 53·0	"

MAGNETIC DECLINATION.—*Continued*

Place.	Tp.	Rge.	Mer.	Date.	Declination.		Observer.
78·91 N.—NE. cor. sec. 24	68	1	Pr.	Aug. 24	12	38·1	G. H. Herriot.
58·45 N.— " 13	70	1	"	Sept. 10	14	26·3	"
35·00 N.— " 24	70	1	"	" 11	14	50·0	"
26·29 N.— " 1	72	1	"	" 30	14	14·6	"
" " 1	72	1	"	" 30	14	11·5	"
76·50 N.— " 12	72	1	"	" 30	11	54·9	"
At NE. cor. sec. 33	17	2	"	Dec. 28	12	37·3	G. A. Bennett.
" " 3	18	2	"	" 26	12	37·3	"
" " 9	18	2	"	" 27	12	39·4	"
16·00 N.—NE. cor. sec. 7	21	2	"	Aug. 26	13	37·3	"
" " 7	21	2	"	" 26	13	36·9	"
At NE. cor. sec 7	21	2	"	" 26	13	35·3	"
16·00 E.—NE. cor. sec. 7	21	2	"	" 26	13	30·9	"
" " 7	21	2	"	" 26	13	30·8	"
67·42 W.— " 35	56	2	"	July 16	14	01·1	O. Rolfson.
At NE. cor. sec. 33	56	2	"	" 17	14	12·8	"
29·87 W.—NE. cor. sec. 31	56	2	"	" 19	14	53·0	"
24·42 W.— " 34	64	2	"	Aug. 19	14	03·3	"
47·50 W.— " 35	60	3	"	Nov. 22	14	14·3	"
10·00 N.— " 22	21	4	"	" 27	13	48·0	A. G. Stuart.
" " 22	21	4	"	" 27	13	46·8	"
5·00 S.—¼ post E. by sec. 23	21	4	"	" 5	13	49·4	"
" " 23	21	4	"	" 5	13	49·0	"
At NE. cor. sec. 35	64	4	"	Sept. 3	14	38·2	O. Rolfson.
At NE. cor. sec. 5	22	5	"	Oct. 4	13	16·1	C. F. Aylsworth
4·00 N.—NE. cor. sec. 4	22	5	"	" 30	13	26·2	"
23·00 W.— " 21	22	5	"	" 30	13	26·1	"
3·00 S.— " 19	22	5	"	" 30	13	27·3	"
20·00 E.— " 19	22	5	"	" 30	13	30·1	"
4·00 W.— " 3	22	5	"	Nov. 5	13	34·7	"
20·00 N.— " 3	22	5	"	" 5	13	33·9	"
5·00 W.— " 10	22	5	"	" 6	13	26·4	"
35·00 S.— " 11	22	5	"	" 7	13	37·7	"
12·00 S.— " 22	22	5	"	" 8	13	15·8	"
35·00 E.— " 10	22	5	"	" 9	13	28·1	"
5·00 W.— " 14	22	5	"	" 11	13	29·0	"
10·00 W.— " 26	22	5	"	" 28	12	26·9	"
20·00 N.— " 26	22	5	"	" 28	11	55·6	"
12·00 S.— " 25	22	5	"	" 29	13	20·3	"
25·00 W.— " 25	22	5	"	" 29	13	06·0	"
14·00 W.— " 6	23	5	"	Oct. 29	13	23·6	"
At SE. cor. sec. 5	23	5	"	" 26	13	23·8	"
7·00 E.—SE. cor. sec. 5	23	5	"	" 26	13	24·5	"
10·00 W.— " 2	23	5	"	Nov. 26	14	07·8	"
15·00 N.— " 2	23	5	"	" 26	13	51·6	"
59·67 W.—NE. " 31	60	5	"	Dec. 9	13	47·1	O. Rolfson.
16·70 W.— " 33	64	5	"	Sept. 16	13	48·9	"
26·00 W.— " 29	21	7	"	May 19	13	06·5	G. A. Bennett.
" " 29	21	7	"	" 19	13	05·4	"
" " 29	21	7	"	" 19	13	05·6	"
" " 29	21	7	"	" 19	13	03·5	"
" " 29	21	7	"	" 19	13	02·9	"
" " 29	21	7	"	" 19	13	03·9	"
" " 29	21	7	"	" 19	13	07·6	"
" " 29	21	7	"	" 19	13	11·8	"
" " 29	21	7	"	" 19	13	11·0	"
" " 29	21	7	"	" 19	13	08·0	"
8·00 N.—NW. cor. sec. 36	21	7	"	Sept. 3	12	56·9	"
At NW. cor. sec. 7	28	7	"	July 29	13	26·7	P.R.A.Belanger.
20·00 S.—NE. cor. sec. 6	29	7	"	Aug. 8	13	16·6	"
77·15 W.—NE. " 36	60	7	"	Dec. 13	14	07·2	O. Rolfson.
8·00 N.—NW. " 36	21	8	"	Sept. 3	12	59·2	G. A. Bennett.
24·00 W.—NE. " 10	28	8	"	July 27	13	03·7	P.R.A.Belanger.
15·00 W.— " 10	29	8	"	Aug. 2	13	29·3	"
9·19 W.— " 35	60	8	"	Dec. 25	17	24·7	O. Rolfson.
1·00 N.— " 31	5	9	"	Oct. 1	13	56·5	G. A. Bennett.
" " 31	5	9	"	" 1	13	58·3	"
38·00 S.— " 14	31	9	"	Nov. 23	13	54·8	A. G. Stuart.
" " 14	31	9	"	" 23	14	00·8	"
" " 14	31	9	"	" 23	13	56·3	"
At NE. cor. sec. 30	18	10	"	July 16	12	54·1	G. A. Bennett.

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
At NE. cor. sec. 30	18	10	Pr.	July 16	12 58·0	G. A. Bennett.
" " 30	18	10	"	" 16	12 58·0	"
22·00 N.—NE. cor. sec. 5	21	11	"	" 6	14 03·2	J. Francis.
21·00 N.— " 8	21	11	"	" 9	14 04·3	"
18·00 W.— " 5	21	11	"	" 11	13 58·2	"
1·00 N.— " 3	21	11	"	" 17	13 54·9	"
3·00 N.— " 14	21	11	"	" 25	13 54·0	"
At NE. cor. sec. 11	21	11	"	" 26	14 04·7	"
45·00 N.—NE. cor. sec. 27	21	11	"	" 30	13 54·1	"
69·00 N.— " 26	21	11	"	Aug. 1	14 05·4	"
26·00 N.— " 20	21	11	"	" 5	13 53·4	"
64·00 N.— " 20	21	11	"	" 7	13 07·9	"
At NW. cor. sec. 31	8	12	"	" 19	14 57·3	P.R.A.Belanger.
At NE. " 36	20	12	"	July 3	14 21·5	J. Francis.
50·00 S.—NE. cor. sec. 7	21	12	"	Dec. 26	14 01·9	W. J. Deans.
18·00 S.— " 7	21	12	"	June 13	14 50·7	J. Francis.
32·00 E.— " 16	21	12	"	Aug. 28	14 41·2	"
At NE. cor. sec. 18	21	12	"	Sept. 18	14 43·9	"
41·00 S.—NE. cor. sec. 36	22	12	"	Aug. 20	14 41·2	"
38·00 W.— " 19	22	12	"	Dec. 31	14 56·7	W. J. Deans.
70·00 S.— " 3	21	13	"	" 23	14 25·9	"
72·00 S.— " 2	21	13	"	" 24	15 02·1	"
18·00 W.— " 5	21	13	"	June 24	15 03·6	J. Francis.
36·00 N.— " 13	21	13	"	April 24	14 54·6	"
37·50 N.— " 25	21	13	"	" 25	14 51·3	"
39·50 W.— " 35	21	13	"	" 26	14 27·4	"
At NE. cor. sec. 34	21	13	"	" 28	14 05·3	"
" " 26	21	13	"	May 1	14 27·5	"
15·00 W.—NE. cor. sec. 14	21	13	"	" 2	14 44·1	"
27·00 E... " 23	21	13	"	" 8	14 44·9	"
32·00 E.— " 22	21	13	"	" 9	14 45·2	"
26·00 E.— " 15	21	13	"	" 10	14 48·4	"
68·00 N.— " 34	21	13	"	" 16	14 34·4	"
41·00 S.— " 2	21	13	"	" 27	14 59·1	"
47·00 W.— " 12	21	13	"	" 28	14 51·5	"
55·00 S.— " 3	21	13	"	" 29	14 56·1	"
17·00 E.— " 2	21	13	"	" 31	14 49·5	"
10·00 N.— " 18	21	13	"	June 8	14 46·3	"
19·00 E.— " 18	21	13	"	" 12	14 44·0	"
25·00 W.— " 19	21	13	"	" 14	15 23·4	"
60·00 W.— " 15	22	13	"	Dec. 28	14 08·2	W. J. Deans.
35·00 W.— " 36	22	13	"	May 15	14 55·5	J. Francis.
45·00 N.— " 4	22	13	"	" 18	14 47·3	"
20·00 W.— " 3	22	13	"	" 21	14 30·1	"
38·00 W.— " 10	22	13	"	" 22	14 41·3	"
9·00 E.— " 15	22	13	"	" 23	14 41·7	"
8·00 S.— " 17	22	13	"	June 18	14 58·4	"
40·00 W.— " 4	22	13	"	" 19	14 44·2	"
17·00 N.— " 6	22	13	"	" 20	15 15·2	"
At NE. cor. sec. 25	21	14	"	" 7	14 50·9	"
" " 23	30	15	"	Dec. 18	15 27·9	G. A. Bennett.
14·00 E.—NE. cor. sec. 8	33	19	"	June 17	15 43·7	"
" " 8	33	19	"	" 16	15 38·5	"
8·00 E.— " 31	19	20	"	Aug. 1	14 09·0	"
34·00 E.— " 9	37	20	"	July 4	16 52·8	P.R.A.Belanger
At SE. cor. sec. 3	38	20	"	" 10	19 10·9	"
8·00 N.—NE. cor. sec. 36	19	21	"	" 27	14 28·7	G. A. Bennett.
52·00 N.— " 36	19	21	"	" 29	14 25·8	"
At NE. cor. sec. 32	34	21	"	June 24	16 16·2	P.R.A.Belanger.
15·00 S.—NE. cor. sec. 3	35	21	"	" 20	16 12·9	"
15·00 S.— " 12	55	26	"	July 13	19 33·8	E. W. Berry.
16·00 S.— " 23	55	26	"	" 31	18 37·8	"
66·00 S.— " 2	55	26	"	Aug. 8	19 15·3	"
60·00 S.— " 30	57	26	"	Dec. 28	18 30·8	"
68·00 S.— " 29	52	28	"	Aug. 22	18 05·5	"
52·00 E.— " 19	52	28	"	" 26	17 36·4	"
68·00 E.— " 23	52	28	"	" 29	19 19·6	"
20·00 N.— " 4	53	28	"	July 18	18 48·3	"
16·00 N.— " 3	53	28	"	" 22	19 31·3	"
32·00 S.— " 15	53	28	"	Sept. 9	19 16·2	"
8·00 E.— " 33	51	29	"	Oct. 5	18 43·5	"

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
62·00 E.—NE. cor. sec. 32	51	29	Pr.	Oct. 10	18 46·0	E. W. Berry.
41·00 S.— " 1	52	29	"	Sept. 17	19 06·0	"
36·00 S.— " 9	52	29	"	Oct. 25	19 32·8	"
41·00 N.— " 5	52	29	"	" 16	19 11·7	"
At NE. cor. sec. 4	28	30	"	" 25	16 20·6	G. A. Bennett.
" " 4	28	30	"	" 25	16 21·1	"
6·00 E.—NE. cor. sec. 33	18	31	"	" 29	17 41·4	"
At NE. cor. sec. 36	18	31	"	" 31	16 43·7	"
32·00 E.—NE. cor. sec. 32	18	31	"	Nov. 1	17 40·5	"
At NE. cor. sec. 36	18	31	"	" 2	16 34·6	"
23·50 E.—NE. cor. sec. 35	18	31	"	" 2	16 50·0	"
10·00 W.— " 31	18	31	"	" 2	17 36·0	"
48·00 E.—SE. " 5	19	31	"	" 1	17 35·1	"
At SE. cor. sec. 1	19	31	"	" 1	17 08·1	"
5·00 E.—SE. cor. sec. 3	18	32	"	" 8	17 45·0	"
At NE. cor. sec. 31	18	32	"	" 9	17 53·7	"
At SE. " 24	31	32	"	Oct. 26	17 12·9	"
" " 24	31	32	"	" 26	17 06·2	"
45·00 W.—NE. cor. sec. 35	18	33	"	Nov. 11	18 05·3	"
12·00 W.— " 32	18	33	"	" 13	17 58·2	"
40·00 E.— " 32	18	33	"	" 15	17 57·4	"
50·00 W.—SE. " 2	19	33	"	" 12	18 09·2	"
30·00 N.—SE. cor. sec. 1	19	1	2	Nov. 14	18 04·9	G. A. Bennett.
14·00 S.—NE. " 28	34	1	2	June 10	19 33·9	"
40·00 N.— " 28	34	1	2	" 11	19 46·8	"
40·00 N.— " 28	34	1	2	" 11	19 37·1	"
16·67 N.— " 13	61	1	2	" 26	19 52·0	J. A. Fletcher.
" " 13	61	1	2	" 26	19 51·7	"
" " 13	61	1	2	" 27	19 50·5	"
" " 13	61	1	2	" 27	19 50·1	"
" " 13	61	1	2	" 28	19 48·2	"
" " 13	61	1	2	" 28	19 48·1	"
36·00 S.— " 34	26	2	2	Sept. 16	19 49·2	B. H. Segre.
20·00 E.— " 35	14	4	2	Aug. 13	17 11·2	G. A. Bennett.
" " 35	14	4	2	" 13	17 00·0	"
At NE. cor. sec. 32	13	5	2	Dec. 7	17 44·5	"
" " 9	14	5	2	" 3	17 49·1	"
" " 8	15	5	2	Nov. 30	17 56·2	"
30·00 W.—NE. cor. sec. 19	26	6	2	" 22	18 13·6	"
36·00 S.— " 29	40	8	2	May 24	20 18·3	P.R.A.Belanger.
At NE. cor. sec. 31	39	9	2	June 6	19 41·7	"
10·00 N.—NE. cor. sec. 19	40	9	2	" 2	20 05·7	"
At SE. cor. sec. 5	41	9	2	May 29	20 15·0	"
38·00 N.—SE. cor. sec. 32	45	9	2	Aug. 19	20 34·4	W. J. Deans.
3·00 E.—NE. cor. sec. 31	56	9	2	Jan. 11	19 18·5	E. W. Robinson.
20·00 W.— " 18	45	10	2	Oct. 24	20 26·6	G. A. Bennett.
10·00 E.— " 18	45	10	2	" 24	20 20·9	"
40·00 W.— " 18	45	10	2	" 24	20 27·3	"
20·00 W.— " 36	45	10	2	Aug. 17	20 20·6	W. J. Deans.
At NE. cor. sec. 36	45	10	2	" 18	19 50·7	"
10·00 W.—NE. cor. sec. 36	56	10	2	Jan. 12	18 58·1	E. W. Robinson
24·00 W.— " 33	56	10	2	" 15	18 21·1	"
At NE. cor. sec. 13	45	11	2	Oct. 24	20 07·7	G. A. Bennett.
65·00 W.—NE. cor. sec. 34	56	11	2	Jan. 18	18 27·8	E. W. Robinson
16·50 W.— " 31	56	11	2	" 20	20 23·0	"
55·00 W.— " 35	56	12	2	" 22	21 46·1	"
73·00 W.— " 34	56	12	2	" 23	21 59·6	"
20·00 W.— " 31	56	12	2	" 25	21 11·5	"
5·00 W.— " 33	56	13	2	" 27	21 03·2	"
3·00 W.— " 32	56	13	2	" 30	21 39·0	"
68·00 S.— " 31	6	14	2	June 23	17 22·3	G. A. Bennett.
" " 31	6	14	2	" 23	17 18·0	"
" " 31	6	14	2	" 23	17 17·4	"
At NE. cor. sec. 11	27A	14	2	July 22	19 33·6	F. V. Seibert.
" " 11	27A	14	2	" 20	19 27·8	"
" " 11	27A	14	2	" 23	19 26·5	"
" " 11	27A	14	2	" 25	19 30·8	"
56·00 W.—NE. cor. sec. 35	56	14	2	Feb. 1	21 50·1	E. W. Robinson.
50·00 W.— " 32	56	14	2	" 3	21 27·5	"
5·00 W.— " 33	56	15	2	" 6	21 42·3	"

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
41·00 N.—NE. cor. sec. 35	4	16	2	Aug. 17	18 03·5	G. A. Bennett.
" " 35	4	16	2	" 17	18 00·4	"
40·00 N.— " 35	4	16	2	" 17	18 16·4	"
51·00 E.— " 32	56	16	2	Feb. 12	21 48·4	E. W. Robinson.
38·00 W.— " 34	56	17	2	" 16	21 43·7	"
75·00 W.— " 33	56	17	2	" 17	21 41·9	"
46·00 W.— " 31	56	17	2	" 19	22 51·2	"
At NE. cor. sec. 31	52	18	2	Nov. 4	20 36·0	P.R.A.Belanger.
At SE. cor. sec. 6	53	18	2	" 5	20 37·4	"
17·58 W.—NE. cor. sec. 34	56	18	2	Feb. 22	23 28·0	E. W. Robinson.
" " 34	56	18	2	" 23	23 24·5	"
65·00 W.— " 33	56	18	2	" 23	23 19·3	"
65·00 W.— " 33	56	18	2	" 24	23 15·7	"
15·00 S.— " 36	27	19	2	Sept. 7	19 09·1	B. H. Segre.
18·00 S.— " 1	33	19	2	Nov. 22	20 10·8	C. Rinfret.
40·00 S.—NW. " 30	46	19	2	July 22	21 44·7	R. C. Purser.
64·00 W.—NE. " 35	56	19	2	Feb. 26	23 35·4	E. W. Robinson.
75·45 W.— " 31	56	19	2	" 28	23 01·1	"
At SW. cor. frac. sec. 36A	46	20	2	Sept. 26	21 58·4	R. C. Purser.
At NE. cor. sec. 32	52	20	2	Nov. 1	22 07·2	P.R.A.Belanger.
At SE. cor. sec. 5	53	20	2	" 1	22 06·9	"
75·00 W.—NE. cor. sec. 35	56	20	2	Feb. 29	23 23·6	E. W. Robinson.
10·00 W.— " 33	56	20	2	Mar. 1	23 14·5	"
27·00 W.— " 32	56	20	2	" 2	23 20·4	"
48·00 W.— " 31	56	20	2	" 4	23 15·4	"
10·00 S.— " 16	13	24	2	June 24	19 06·6	C. Rinfret.
10·00 N.— " 7	14	24	2	" 18	19 26·1	"
At NE. cor. sec. 31	15	25	2	Nov. 26	19 19·3	G. A. Bennett.
" " 21	24	25	2	July 15	20 09·9	F. V. Seibert.
40·00 S.—NE. cor. sec. 20	26	25	2	" 16	19 39·8	"
40·50 E.— " 34	15	26	2	Nov. 25	19 16·1	G. A. Bennett.
" " 34	15	26	2	" 25	19 17·1	"
10·00 W.—SE. " 6	31	26	2	Oct. 9	21 33·8	B. H. Segre.
40·00 S.—NE. " 2	24	27	2	Nov. 5	20 33·5	"
At SE. cor. sec. 2	43	28	2	Sept. 21	21 13·6	R. C. Purser.
41·84 N.—NE. cor. sec. 36	13	29	2	July 13	19 27·9	C. Rinfret.
At NW. cor. sec. 19	14	29	2	" 23	19 48·6	"
15·00 S.—NE. cor. sec. 34	14	29	2	Aug. 9	19 58·1	"
1·00 S.— " 20	14	29	2	" 10	19 38·5	"
20·00 N.— " 25	7	1	3	July 2	19 28·9	F. V. Seibert.
5·00 S.— " 17	14	1	3	" 17	20 01·6	C. Rinfret.
5·00 S.— " 10	14	1	3	Oct. 25	20 32·8	"
At SE. cor. sec. 5	39	1	3	June 10	22 17.5	R. C. Purser.
20·00 E.—NE. cor. sec. 11	54	1	3	Sept. 24	23 27·3	P.R.A.Belanger.
At NE. cor. sec. 9	55	1	3	Oct. 2	23 40·4	"
" " 7	56	1	3	Sept. 25	22 52·1	"
30·00 S.—NE. cor. sec. 13	57	1	3	July 24	23 11·9	J. A. Fletcher.
" " 13	57	1	3	" 24	23 12·6	"
" " 13	57	1	3	" 25	23 12·9	"
" " 13	57	1	3	" 25	23 13·5	"
" " 13	57	1	3	" 27	23 12·3	"
" " 13	57	1	3	" 27	23 13·5	"
78·00 N.— " 36	64	1	3	April 14	23 44·0	A. Saint-Cyr.
70·00 N.— " 25	65	1	3	" 19	24 23·7	"
14·00 N.— " 36	65	1	3	" 22	24 09·1	"
23·00 N.— " 25	66	1	3	May 2	23 54·3	"
33·00 N.— " 36	66	1	3	" 6	23 44·8	"
39·00 N.— " 2	67	1	3	" 10	23 45·6	"
22·00 N.— " 24	67	1	3	" 14	23 45·2	"
24·00 N.— " 12	68	1	3	" 23	23 28·2	"
76·00 W.— " 32	68	1	3	June 4	23 24·3	"
37·00 N.— " 28	13	2	3	Aug. 2	20 36·2	C. Rinfret.
29·00 S.— " 3	14	2	3	July 29	20 33·0	"
18·00 W.— " 36	68	2	3	June 5	23 56·7	A. Saint-Cyr.
47·00 W.— " 35	68	2	3	" 11	21 59·5	"
68·00 W.— " 35	68	2	3	" 12	22 11·4	"
33·00 W.— " 33	68	2	3	" 13	22 20·0	"
30·00 S.— " 21	25	3	3	Oct. 23	21 01·0	B. H. Segre.
20·00 N.— " 25	34	3	3	May 22	22 43·6	R. C. Purser.
48·00 W.— " 36	68	3	3	June 17	21 12·8	A. Saint-Cyr.
60·00 W.— " 33	68	3	3	" 20	24 06·6	"

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
64·00 W.—NE. cor. sec. 32	68	3	3	June 22	25 09·3	A. Saint Cyr.
10·00 W.— " 36	68	4	3	" 24	26 02·0	"
54·00 W.— " 33	68	4	3	" 28	23 44·6	"
At NE. cor. sec. 19	49	5	3	Oct. 8	20 37·2	R. C. Purser.
65·00 S.—NE. cor. sec. 6	49	5	3	" 9	20 46·4	"
30·00 E.— " 7	49	5	3	" 4	20 53·7	"
2·50 W.— " 36	68	5	3	July 5	22 51·7	A. Saint-Cyr.
50·00 W.— " 36	68	5	3	" 8	24 34·9	"
54·00 W.— " 33	68	5	3	" 12	23 51·0	"
53·00 W.— " 32	68	5	3	" 15	23 28·6	"
60 00 W.— " 31	68	5	3	" 16	23 07·8	"
At ¼ post N. by sec. 24	33	6	3	Aug. 29	22 56·1	R. C. Purser.
3·40 S.—NE. cor. sec. 18	49	6	3	Oct. 14	21 54·9	"
65·10 W.—SW. " 16	49	6	3	" 15	21 17·3	"
13·81 W.—NE. cor. sec. 18	49	6	3	Nov. 28	21 31·6	R. C. Purser.
10·00 S.—NW. " 20	56	6	3	Oct. 15	22 26·9	P.R.A.Belanger.
74·00 W.—NE. " 36	68	6	3	July 20	23 53·2	A. Saint-Cyr.
60·00 W.— " 35	68	6	3	" 22	25 19·4	"
48·00 W.— " 34	68	6	3	" 23	24 43·5	"
60·00 W.— " 34	68	6	3	" 24	24 42·2	"
18·00 W.— " 32	68	6	3	" 25	23 25·3	"
46·00 W.— " 31	68	6	3	" 26	25 22·2	"
At NE. cor. sec. 6	26	7	3	May 24	21 40·1	F. V. Seibert.
" " 6	26	7	3	" 25	21 32·5	"
3·70 S.—NE. cor. sec. 36	49	7	3	Oct. 16	22 21·3	R. C. Purser.
32·00 E.— " 24	49	7	3	Nov. 26	21 29·6	"
37·00 E.— " 24	49	7	3	" 26	21 25·6	"
37·00 E.— " 24	49	7	3	" 27	21 32·5	"
10·00 W.— " 24	56	7	3	Oct. 13	22 41·4	P.R.A.Belanger.
40·00 W.— " 12	57	7	3	" 8	22 45·2	"
56·00 W.— " 34	68	7	3	July 29	25 09·4	A. Saint-Cyr.
17·00 W.— " 32	68	7	3	" 30	24 33·8	"
5·00 E.— " 22	53	8	3	June 17	21 43·0	W. J. Deans.
At NE. cor. sec. 21	54	8	3	" 14	22 25·7	"
8·00 W.—SE. cor. sec. 4	55	8	3	" 15	21 32·0	"
13·00 W.—NE. cor. sec. 36	68	8	3	Aug. 1	24 47·2	A. Saint-Cyr.
74·00 W.— " 36	68	8	3	" 2	25 28·6	"
73·00 W.— " 35	68	8	3	" 3	25 34·4	"
32·00 W.— " 33	68	8	3	" 5	24 48·8	"
56·00 W.— " 32	68	8	3	" 6	24 22·5	"
67·00 W.— " 36	68	9	3	" 8	25 05·1	"
25·00 W.— " 34	68	9	3	" 14	25 58·3	"
28·00 W.— " 33	68	9	3	" 15	25 57·3	"
42·00 W.— " 32	68	9	3	" 16	26 08·6	"
38·50 W.— " 31	68	9	3	" 17	26 00·9	"
At NE. cor. sec. 31	16	10	3	Oct. 1	21 26·6	F. V. Seibert.
50·00 E.—NE. cor. sec. 31	31	10	3	May 28	21 57·8	R. C. Purser.
At NE. cor. sec. 32	32	10	3	June 3	21 52·8	"
46·00 W.—NE. cor. sec. 36	68	10	3	Aug. 19	26 56·6	A. Saint-Cyr.
47·00 W.— " 32	68	10	3	" 21	27 45·7	"
At NE. cor. sec. 36	16	11	3	Sept. 28	21 34·0	F. V. Seibert.
" " 36	16	11	3	Oct. 7	21 22·7	"
40·00 S.—NE. cor. sec. 2	17	11	3	" 4	20 59·5	"
At NE. cor. sec. 1	17	11	3	" 6	21 24·4	"
" " 2	17	11	3	" 3	21 10·7	"
40·00 S.—NE. cor. sec. 2	17	11	3	May 31	21 25·0	"
40·00 S.— " 2	17	11	3	June 21	21 19·7	"
3·00 W.— " 36	68	11	3	Aug. 22	27 48·4	A. Saint-Cyr.
49·00 W.— " 35	68	11	3	" 27	27 57·2	"
55·00 W.— " 32	68	11	3	" 30	26 54·4	"
67·00 W.— " 31	68	11	3	" 31	26 35·3	"
20·00 W.— " 31	50	12	3	July 4	23 53·1	W. J. Deans.
70·00 W.— " 31	50	12	3	" 5	24 19·4	"
20·00 W.—SE. " 6	51	12	3	June 29	24 36·8	"
At NE. cor. sec. 6	51	12	3	July 9	23 56·1	"
56·57 W.—NE. cor. sec. 18	61	12	3	Aug. 14	26 00·3	C. F. Miles.
55·44 W.— " 18	61	12	3	" 14	26 04·1	"
6·00 W.— " 35	68	12	3	Sept. 2	26 26·1	A. Saint-Cyr.
44·00 W.— " 34	68	12	3	" 3	26 29·8	"
26·00 W.— " 33	68	12	3	" 4	27 19·8	"
8·00 W.— " 31	68	12	3	" 9	22 44·4	"

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
60·00 S.—NE. cor. sec. 15	16	13	3	June 9	21 44·2	F. V. Seibert.
20·00 S.— " 15	16	13	3	" 11	21 51·4	"
20·00 S.— " 15	16	13	3	" 13	21 44·4	"
At NE. cor. sec. 26	26	13	3	Sept. 24	21 09·2	"
" " 25	26	13	3	" 24	21 06·6	"
80·00 W.—NE. cor. sec. 36	68	13	3	" 10	26 40·8	A. Saint-Cyr.
7·00 W.— " 34	68	13	3	" 11	26 26·3	"
14·00 W.— " 31	68	13	3	" 23	26 22·9	"
1·25 S.— " 8	13	14	3	July 16	20 43·9	S. L. Evans.
At NE. cor. sec. 9	13	14	3	" 17	20 58·3	"
22·00 W.—NE. cor. sec. 35	68	14	3	Sept. 25	25 39·2	A. Saint-Cyr.
57·00 W.— " 34	68	14	3	" 26	25 47·8	"
67·00 W.— " 33	68	14	3	" 28	25 50·3	"
40·00 N.— " 32	68	14	3	" 29	25 42·4	"
40·00 N.— " 32	68	14	3	" 29	25 43·6	"
At NE. cor. sec. 27	19	15	3	Aug. 4	22 21·3	F. V. Seibert.
26·70 W.—NE. cor. sec. 3	48	15	3	July 2	24 41·7	R. C. Purser.
40·00 N.— " 11	47	16	3	June 25	23 53·2	"
At NE. cor. sec. 11	47	16	3	" 26	24 14·6	"
" " 22	18	17	3	" 17	21 30·6	F. V. Seibert.
40·00 S.—NE. cor. sec. 21	17	18	3	" 7	21 07·4	"
At ¼ post—N. by sec. 20	36	19	3	Sept. 16	23 14·7	R. C. Purser.
At SW. cor. sec. 6	47	19	3	" 25	21 59·7	"
0·98 W.—NE. cor. sec. 19	8	22	3	June 4	21 49·1	S. L. Evans.
0·53 S.— " 21	8	22	3	" 7	21 43·6	"
0·23 S.— " 22	8	22	3	" 7	21 37·0	"
7·00 W.— " 20	8	22	3	" 8	21 44·6	"
0·16 S.— " 24	8	22	3	" 10	21 41·9	"
0·21 N.— " 23	8	22	3	" 10	21 39·0	"
0·23 S.— " 8	8	22	3	" 12	21 40·5	"
0·10 W.— " 7	8	22	3	" 18	21 40·9	"
5·00 W.— " 9	8	22	3	" 19	21 40·0	"
0·34 S.— " 10	8	22	3	" 19	21 39·5	"
0·30 S.— " 11	8	22	3	" 20	21 38·9	"
At ¼ post—E. by sec. 33	53	22	3	" 19	24 37·8	R. C. Purser.
40·00 E.—NE. cor. sec. 7	14	23	3	Sept. 27	22 06·8	C. Rinfret.
35·00 N.— " 11	15	23	3	" 24	22 14·9	"
0·35 W.— " 11	6	24	3	June 25	20 37·5	S. L. Evans.
8·00 W.— " 10	6	24	3	" 25	20 16·1	"
50·00 W.— " 9	6	24	3	" 25	19 58·0	"
7·00 W.— " 22	6	24	3	July 2	20 46·5	"
0·50 S.— " 9	6	24	3	" 6	19 53·5	"
23·00 W.— " 8	6	24	3	Aug. 12	20 07·0	"
2·03 S.— " 7	6	24	3	" 12	20 24·1	"
20·00 W.— " 22	15	24	3	Sept. 14	22 01·0	C. Rinfret.
10·00 W.— " 11	6	25	3	Aug. 6	21 44·2	S. L. Evans.
0·50 W.— " 10	6	25	3	" 6	22 22·3	"
1·00 S.— " 9	6	25	3	" 8	23 16·9	"
8·00 N.— " 20	6	25	3	" 9	23 08·0	"
0·50 S.— " 7	6	25	3	" 26	23 07·2	"
0·50 E.— " 8	6	25	3	" 26	23 15·7	"
0·60 W.— " 21	6	25	3	" 26	23 21·7	"
20·00 E.— " 36	13	25	3	" 27	22 33·1	C. Rinfret.
50·00 S.— " 30	53	25	3	" 7	24 22·7	G. J. Lonergan.
0·25 E.— " 32	5	26	3	" 21	22 27·2	S. L. Evans.
2·00 E.— " 9	6	26	3	" 15	22 18·8	"
" " 9	6	26	3	" 15	22 20·5	"
0·15 W.— " 33	6	26	3	" 21	22 39·2	"
0·30 W.— " 21	6	26	3	" 24	22 16·9	"
9·50 S.— " 22	6	26	3	" 29	22 24·1	"
15·00 N.— " 14	6	26	3	" 30	22 33·9	"
At NE. cor. sec. 33	37	26	3	" 19	22 36·5	R. C. Purser.
57·00 S.—NE. cor. sec. 14	6	27	3	Sept. 4	21 52·4	S. L. Evans.
0·60 W.— " 8	7	28	3	" 11	21 50·5	"
5·00 E.— " 7	7	28	3	" 9	21 57·0	"
0·25 E.— " 9	7	28	3	" 11	21 49·0	"
0·60 E.— " 11	7	28	3	" 2	21 42·0	"
0·40 N.— " 10	7	28	3	" 12	21 44·4	"
25·00 S.—54° 34′ E. of ¼ post on E. by sec. 21	6	1	4	June 16	21 48·4	E.S.Martindale.
152·50 E.—NE. cor. sec. 1	63	1	4	July 3	25 58·0	C. F. Miles.
48·18 N.— " 13	106	1	4	Sept. 26	30 38·1	J.B. McFarlane.

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
55·95 N.—NE. cor. sec. 36	108	1	4	July 18	30 27·8	J.B. McFarlane.
16·72 N.— " 1	109	1	4	" 19	30 37·8	"
58·02 N.— " 1	109	1	4	" 20	30 35·4	"
67·41 N.— " 25	109	1	4	" 24	30 34·6	"
5·02 N.— " 36	110	1	4	Aug. 6	30 30·6	"
61·74 N.— " 25	111	1	4	" 12	30 22·2	"
4·00 N.— " 25	112	1	4	" 21	32 21·8	"
27·25 N.— " 24	113	1	4	" 27	32 22·9	"
67·59 N.— " 36	114	1	4	Sept. 7	32 50·7	"
11·04 N.— " 1	115	1	4	" 11	32 57·5	"
11·04 N.— " 1	115	1	4	" 13	32 58·2	"
At NE. cor. sec. 16	6	2	4	June 1	21 47·6	E.S. Martindale
Centre sec. 24	8	3	4	Aug. 15	22 09·1	F. V. Seibert.
" 24	8	3	4	" 16	22 06·9	"
" 24	8	3	4	" 17	22 04·5	"
15·00 S.—NE. cor. sec. 10	17	3	4	July 18	23 08·7	G. C. Cowper.
20·00 E.— " 10	17	3	4	" 23	23 10·9	"
20·00 E.— " 10	17	3	4	" 28	23 12·9	"
10·00 E.— " 33	18	3	4	Aug. 4	23 16·5	"
5·00 N.— " 20	18	3	4	" 8	23 17·5	"
10·00 W.— " 20	18	3	4	" 19	23 16·9	"
10·00 E.— " 33	18	3	4	" 24	23 20·5	"
15·00 W.— " 11	19	3	4	July 7	23 20·9	"
At NE. cor. sec. 10	19	3	4	" 7	23 11·7	"
20·00 N.—NE. cor. sec. 16	17	4	4	Sept. 1	23 18·8	"
1·00 E.— " 33	19	4	4	June 5	23 10·3	"
10·00 S.— " 33	19	4	4	" 10	23 13·6	"
42·36 W.— " 31	92	5	4	Oct. 26	29 49·0	J.B. McFarlane.
69·10 W.— " 32	92	5	4	" 27	30 16·2	"
10·00 W.— " 36	1	6	4	June 2	21 54·5	C. M. Walker.
At NE. cor. sec. 8	1	6	4	" 16	22 06·5	"
" " 3	1	6	4	" 23	22 16·7	"
60·00 S.—NE. cor. sec. 1	1	6	4	" 26	22 15·3	"
25·00 N.— " 25	2	6	4	May 24	22 00·7	"
5·00 S.— " 23	2	6	4	" 28	22 08·3	"
18·00 N.— " 8	2	6	4	" 29	22 06·7	"
At NE. cor. sec. 33	2	6	4	" 24	22 22·8	"
59·93 W.—NE. cor. sec. 35	72	7	4	April 6	27 26·4	G. H. Blanchet.
78·22 W.— " 32	72	8	4	" 14	28 01·6	"
30·23 W.— " 33	72	9	4	" 20	27 33·7	"
31·34 N.— " 11	22	10	4	Sept. 22	23 35·5	G. C. Cowper.
" " 11	22	10	4	" 23	23 33·8	"
5·20 W.— " 31	72	10	4	April 29	27 59·4	G. H. Blanchet.
32·43 W.— " 36	76	10	4	May 29	30 14·5	G. McMillan.
At NE. cor, sec. 11	38	11	4	Aug. 30	25 08·7	F. V. Seibert.
40·00 S.—NE. cor. sec. 11	38	11	4	Sept. 2	24 59·8	"
16·01 W.— " 31	72	11	4	May 2	28 19·4	G. H. Blanchet.
25·99 W.— " 32	76	11	4	June 6	30 36·0	G. McMillan.
At NE. cor. sec. 13	24	12	4	Sept. 11	24 28·8	F. V. Seibert.
23·86 W.—NE. cor. sec. 34	72	12	4	May 7	28 02·5	G. H. Blanchet.
77·06 W.— " 36	72	13	4	" 9	28 24·2	"
64·17 W.— " 36	76	13	4	June 16	30 48·9	G. McMillan.
54·35 W.— " 31	76	13	4	" 23	30 18·5	"
At NE. cor. sec. 35	26	14	4	Sept. 10	23 53·2	F. V. Seibert.
3·00 E.—NE. cor. sec. 35	26	14	4	" 11	23 59·8	"
31·06 W.— " 36	72	14	4	May 14	28 37·6	G. H. Blanchet.
45·73 W.— " 36	76	14	4	June 21	30 06·6	G. McMillan.
At SE. cor. sec. 2	27	15	4	Sept. 10	24 19·1	F. V. Seibert.
7·10 W.—NE. cor. sec. 34	72	15	4	May 22	29 05·3	G. H. Blanchet.
46·78 W.— " 33	76	15	4	July 8	28 11·8	G. McMillan.
7·60 W.— " 32	72	16	4	June 1	28 33·5	G. H. Blanchet.
36·68 W.— " 31	76	16	4	July 20	29 34·4	G. McMillan.
28·00 N.— " 8	5	17	4	June 1	22 57·6	P. B. Street.
23·00 N.— " 10	5	17	4	" 6	23 00·2	"
71·33 W.— " 35	72	17	4	" 5	28 45·9	G. H. Blanchet.
38·95 W.— " 33	76	17	4	July 29	29 44·0	G. McMillan.
48·99 W.— " 33	88	17	4	Jan. 3	30 53·3	G. H. Blanchet.
2·00 N.— " 23	5	18	4	June 12	23 04·2	P. B. Street.
10·44 W. 19·69 S.—NE. cor. sec. 33	72	18	4	" 12	28 59·6	G. H. Blanchet.
48·69 W.—NE. cor. sec. 31	72	18	4	" 17	28 56·3	"
71·44 W.— " 36	76	18	4	Aug. 1	29 26·7	G. McMillan.

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
38·88 W.—NE. cor. sec. 31	76	18	4	Aug. 13	29 12·8	G. McMillan
11·49 W.— " 32	88	18	4	Jan. 15	30 44·9	G. H. Blanchet.
20·00 S.— " 24	2	19	4	June 20	22 21·2	P. B. Street.
W.— " 36	72	19	4	" 18	29 02·2	G. H. Blanchet.
60·30 W.— " 32	72	19	4	" 23	29 10·5	"
68·29 W.— " 35	76	19	4	Aug. 17	28 56·5	G. McMillan.
52·89 W.— " 31	88	19	4	Jan. 25	30 42·4	G. H. Blanchet.
14·30 W.— " 32	72	20	4	June 29	28 45·9	"
55·20 W.— " 32	76	20	4	Sept. 6	28 41·3	G. McMillan.
52·41 W.— " 32	88	20	4	Jan. 31	30 19·4	G. H. Blanchet.
13·78 W.— " 36	72	21	4	July 2	28 34·8	"
1·22 W.— " 32	76	21	4	Sept. 11	29 06·7	G. McMillan.
0·86 W.— " 31	88	21	4	Feb. 7	27 50·3	G. H. Blanchet.
At NE. cor. sec. 6	49	22	4	Oct. 17	26 44·2	F. V. Seibert.
" " 6	49	22	4	" 24	26 28·1	"
78·14 W.—NE. cor. sec. 36	76	22	4	Sept. 17	29 09·5	G. McMillan.
55·64 W.— " 32	76	22	4	" 24	28 36·8	"
22·00 W.— " 34	88	22	4	Feb. 9	27 24·4	G. H. Blanchet.
78·00 W.— " 32	72	23	4	July 18	28 36·2	"
26·35 W.— " 33	76	23	4	Sept. 30	28 50·4	G. McMillan.
1·00 W.— " 35	88	23	4	Feb. 13	29 53·3	G. H. Blanchet.
71·10 W.— " 35	72	24	4	July 20	29 09·8	"
64·42 W.— " 32	76	24	4	Oct. 9	29 36·0	G. McMillan.
65·00 W.— " 34	88	24	4	Feb. 20	30 30·2	G. H. Blanchet.
17·05 W.— " 33	72	25	4	July 29	29 05·2	"
19·04 W.— " 32	76	25	4	Oct. 16	29 01·7	G. McMillan.
At NE. cor. sec. 34	88	25	4	Mar. 4	30 19·4	G. H. Blanchet.
18·60 W.—NE. cor. sec. 34	72	26	4	Aug. 6	28 46·2	"
18·00 W.— " •34	76	26	4	Oct. 26	29 12·1	G. McMillan.
30·00 N.— " 27	50	28	4	Nov. 12	27 16·3	R. C. Purser.
NE. Bk. 7—Villa lots, SW. ¼ sec. 26	1	30	4	Sept. 16	21 50·4	F. V. Seibert.
16·76 S.—NE. cor. sec. 13	24	1	5	" 11	25 22·4	J. A. Fletcher.
" " 13	24	1	5	" 12	25 22·8	"
At NE. cor. sec. 25	50	1	5	Aug. 13	27 02·8	R. C. Purser.
60·75 W.—NE. cor. sec. 35	88	1	5	April 10	31 07·4	A. H. Hawkins.
At NE. cor. sec. 31	88	1	5	" 15	30 35·0	"
38·00 N.—NE. cor. sec. 35	11	2	5	Nov. 4	24 11·1	P. B. Street.
2·00 N.— " 28	11	2	5	" 20	24 09·2	"
8·00 S.— " 21	12	2	5	Dec. 4	24 13·8	"
28·00 S.— " 34	12	2	5	" 12	24 05·8	"
44·64 W.— " 36	88	2	5	April 16	30 49·0	A. H. Hawkins.
52·06 W.— " 31	88	2	5	" 17	31 11·5	"
44·00 W.— " 33	88	2	5	" 18	30 17·3	"
44·00 W.— " 33	88	2	5	" 19	30 12·2	"
51·00 E.— " 19	10	3	5	Oct. 10	24 00·9	P. B. Street.
10·00 E.— " 10	11	3	5	" 21	23 53·8	"
42·00 S.— " 9	12	3	5	July 26	24 01·2	"
In SE. ¼ sec. 6	12	3	5	" 28	23 49·9	"
53·88 W.—NE. cor. sec. 34	88	3	5	April 23	29 48·0	A. H. Hawkins.
40·82 W.— " 33	88	3	5	" 25	31 00·4	"
7·89 W— " 31	88	3	5	" 27	30 51·3	"
25·00 N.— " 7	11	4	5	Sept. 27	23 36·9	P. B. Street.
68·00 S.— " 20	19	4	5	Nov. 5	24 56·2	S. L. Evans.
60·00 W.— " 32	63	4	5	Oct. 5	29 02·5	G. J. Lonergan.
37·71 W.— " 35	88	4	5	April 30	32 00·8	A. H. Hawkins.
26·00 W.— " 34	88	4	5	May 1	31 09·4	"
7·01 W.— " 32	88	4	5	" [illegible]	29 56·6	"
43·00 S.— " 11	12	5	5	Aug. 25	24 06·9	P. B. Street.
37·00 N.— " 2	13	5	5	" 12	24 04·5	"
12·00 S.— " 25	19	5	5	Oct. 13	25 01·8	S. L. Evans.
43·00 N.— " 12	19	5	5	Nov. 15	25 07·6	"
56·78 S.— " 36	20	5	5	Oct. 2	25 05·6	"
60·00 E.— " 22	64	5	5	" 3	28 30·0	G. J. Lonergan.
11·00 W.— " 36	88	5	5	May 4	31 26·2	A. H. Hawkins.
11·94 W.— " 33	88	5	5	" 6	30 31·8	"
10·88 W.— " 32	88	5	5	" 7	31 32·1	"
72·61 W.— " 31	88	5	5	" 9	31 44·2	"
5·00 W.— " 36	16	6	5	Nov. 18	25 03·5	F. S. Martindale.
20·00 N.— " 24	20	6	5	Oct. 14	25 15·4	S. L. Evans.
20·00 N.— " 24	20	6	5	" 14	25 05·4	"
40·00 S.— " 34	42	6	5	" 30	27 07·7	G. J. Lonergan.

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
12·83 W.—NE. cor. sec. 33	88	6	5	May 13	32 51·5	A. H. Hawkins.
74·03 W.— " 33	88	6	5	" 14	31 56·9	"
43·89 W.— " 31	88	6	5	" 15	31 14·3	"
15·00 S.— " 34	41	7	5	Nov. 4	26 57·6	G. J. Lonergan.
At NE. cor. sec. 35	41	7	5	" 4	26 56·4	"
5·00 W.—NE. cor. sec. 34	41	7	5	" 4	26 57·3	"
1·76 W.—NE. cor. sec. 34	88	7	5	May 21	30 39·0	A. H. Hawkins.
" " 34	88	7	5	" 22	30 29·8	"
57·28 W.— " 33	88	7	5	" 23	30 30·0	"
22·76 W.— " 36	88	8	5	" 28	29 59·9	"
0·91 W.— " 34	88	8	5	" 29	29 18·6	"
0·91 W.— " 34	88	8	5	" 30	29 10·8	"
79·56 W.— " 33	88	8	5	" 31	29 06·9	"
32·47 W.— " 36	88	9	5	June 3	28 33·5	"
0·43 W.— " 33	88	9	5	" 5	30 16·3	"
40·57 W.— " 33	88	9	5	" 7	29 49·5	"
68·85 W.— " 31	88	9	5	" 15	29 44·3	"
40·72 W.— " 36	88	10	5	" 17	29 41·0	"
14·71 W.— " 35	88	10	5	" 18	29 44·2	"
23·96 W.— " 34	88	10	5	" 19	29 42·6	"
0·80 W.— " 33	88	10	5	" 20	29 39·4	"
28·20 W.— " 36	88	11	5	" 24	28 50·8	"
17·88 W.— " 35	88	11	5	" 25	28 35·4	"
40·52 W.— " 32	88	11	5	" 29	29 38·7	"
12·60 N.— " 36	88	12	5	Jan. 5	28 41·1	L. E. Fontaine.
16·34 W.— " 36	88	12	5	July 1	29 23·8	A. H. Hawkins.
5·48 W.— " 35	88	12	5	" 3	28 55·9	"
39·68 W.— " 34	88	12	5	" 4	28 42·3	"
59·10 W.— " 33	88	12	5	" 5	28 34·2	"
71·94 W.— " 36	88	13	5	" 10	28 55·4	"
76·00 W.— " 34	88	13	5	" 11	28 58·5	"
4·28 W.— " 33	88	13	5	" 12	29 27·7	"
64·30 W.— " 31	88	13	5	" 15	28 50·0	"
7·88 N.— " 35	48	14	5	Jan. 19	27 13·4	L. E. Fontaine.
37·32 W.— " 36	88	14	5	July 16	28 59·3	A. H. Hawkins.
0·42 W.— " 33	88	14	5	" 22	30 04·5	"
42·50 W.— " 32	88	14	5	" 23	29 44·2	"
20·59 S.— " 36	49	15	5	Jan. 24	27 39·0	L. E. Fontaine.
3·17 S.— " 4	51	15	5	" 31	27 43·1	"
18·62 W.— " 36	88	15	5	July 24	30 56·4	A. H. Hawkins.
5·34 W.— " 32	88	15	5	" 27	31 04·0	"
At NE. cor. sec. 31	48	16	5	Dec. 7	27 35·7	H. Matheson.
38·00 S.—NE. cor. sec. 31	48	16	5	" 13	27 28·5	"
20·00 W.— " 19	48	16	5	" 15	27 29·2	"
30·00 S.— " 8	49	16	5	" 5	27 35·3	"
36·00 S.— " 4	49	16	5	" 4	27 31·6	"
30·00 E.— " 7	49	16	5	" 6	27 40·1	"
4·00 N.— " 6	49	16	5	" 7	27 33·5	"
30·00 W.— " 35	49	16	5	Oct. 15	27 46·1	"
At NE. cor. sec. 35	49	16	5	" 16	27 55·0	"
45·00 S.—NE. cor. sec. 26	49	16	5	" 30	27 55·0	"
42·50 E.— " 23	49	16	5	" 31	27 52·7	"
28·00 W.— " 23	49	16	5	Nov. 1	27 54·7	"
At NE. cor. sec. 34	49	16	5	" 2	27 49·3	"
14·00 N.—NE. cor. sec. 27	49	16	5	" 2	27 52·9	"
38·00 N.— " 22	49	16	5	" 7	27 48·2	"
30·00 N.— " 15	49	16	5	" 13	27 45·1	"
35·00 N.— " 10	49	16	5	" 18	27 41·5	"
2·00 N.— " 14	49	16	5	" 20	27 44·6	"
At NE. cor. sec. 11	49	16	5	" 20	27 37·0	"
27·00 E.—NE. cor. sec. 11	49	16	5	" 21	27 36·2	"
38·00 E.— " 10	49	16	5	" 22	27 36·6	"
30·00 N.— " 9	49	16	5	" 26	27 39·7	"
36·00 N.— " 16	49	16	5	" 28	27 45·1	"
20·00 W.— " 9	49	16	5	" 29	27 39·6	"
30·00 S.— " 2	50	16	5	Oct. 18	27 49·4	"
20·00 S.— " 11	50	16	5	" 21	27 50·2	"
38·00 E.— " 11	50	16	5	" 22	27 53·2	"
18·00 E.— " 10	50	16	5	" 28	27 42·9	"
48·29 W.— " 35	88	16	5	Aug. 1	31 33·3	A. H. Hawkins.
At NE. cor. sec. 29	28	17	5	June 29	24 28·1	N. C. Stewart.

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declin-ation.	Observer.
30·00 S.—NE. cor. sec. 34	48	17	5	Dec. 26	27 34·8	H. Matheson.
6·00 N.— " 26	48	17	5	" 21	27 31·2	"
16·00 S — " 1	49	17	5	" 10	27 34·2	"
9·00 N.— " 1	49	17	5	" 11	27 39·1	"
47·02 W.— " 36	88	17	5	Aug. 6	31 06·0	A. H. Hawkins.
5·70 W.— " 34	88	17	5	" 7	31 03·0	"
20·70 W.— " 31	88	17	5	" 10	31 06·7	"
16·05 S.— " 32	49	18	5	July 4	28 28·0	L. E. Fontaine.
62·50 W.— " 32	88	18	5	Aug. 19	25 21·6	A. H. Hawkins.
52·00 S — " 36	50	19	5	July 9	28 03·4	L. E. Fontaine.
73·07 W.— " 35	88	19	5	Aug. 21	31 45·3	A. H. Hawkins.
42·96 W.— " 33	88	19	5	" 22	31 31·5	"
21·19 W.— " 31	88	19	5	" 23	31 23·7	"
0·85 N.— " 34	50	20	5	May 21	28 16·2	L. E. Fontaine.
8·10 S.— " 9	56	20	5	June 5	29 01·5	"
72·70 N.— " 7	83	20	5	Aug. 8	29 58·6	"
15·96 W.— " 35	88	20	5	" 26	31 03·2	A. H. Hawkins.
25·08 W.— " 31	88	20	5	Sept. 2	31 04·4	"
65·75 N.— " 22	49	21	5	May 3	28 04·1	L. E. Fontaine.
2·05 N.— " 12	50	21	5	" 8	28 04·7	"
6·65 S.— " 22	56	21	5	June 9	29 24·4	"
50·80 N.— " 36	81	21	5	Aug. 5	29 49·7	"
41·89 W.— " 35	88	21	5	Sept. 4	31 23·4	A. H. Hawkins.
19·16 W.— " 34	88	21	5	" 5	31 11·3	"
60·78 W.— " 34	88	21	5	" 6	31 23·2	"
10·00 N.—SE. cor. sec. 10	28	22	5	July 4	25 59·7	N. C. Stewart.
At NE. cor. sec. 10	28	22	5	" 8	26 05·9	"
50·00 N.—SE. cor. sec. 15	28	22	5	" 10	26 09·6	"
40·00 N.— " 22	28	22	5	" 17	26 12·8	"
At NE. cor. sec. 11	28	22	5	" 18	26 18·0	"
20·00 N.—SE. cor. sec. 29	28	22	5	" 22	25 42·8	"
At NE. cor. sec. 35	28	22	5	" 23	26 46·7	"
" " 33	28	22	5	" 29	26 15·2	"
20·00 W.—NE. cor. sec. 36	28	22	5	Aug. 1	26 15·0	"
At NE. cor. sec. 31	28	22	5	" 7	26 11·4	"
" " 32	28	22	5	" 8	26 19·1	"
73·00 S.—NE. cor. sec. 32	28	22	5	" 9	26 16·8	"
At NE. cor. sec. 6	29	22	5	Nov. 5	25 49·5	"
57·00 W.—NE. cor. sec. 6	29	22	5	" 6	26 00·6	"
37·35 S.— " 21	71	22	5	" 1	29 50·7	L. E. Fontaine.
38·80 N.— " 6	84	22	5	Aug. 13	31 51·7	"
At NE. cor. sec. 36	88	22	5	Sept. 10	31 43·1	A. H. Hawkins.
69·35 W.—NE. cor. sec. 36	88	22	5	" 11	31 40·7	"
16·36 W.— " 32	88	22	5	" 13	31 49·5	"
33·00 N.—SE. " 1	29	23	5	Nov. 7	26 22·0	N. C. Stewart.
27·00 N.—NE. " 1	29	23	5	" 8	26 14·9	"
3·00 W.— " 12	29	23	5	" 9	26 09·5	"
At NE. cor. sec. 11	29	23	5	" 14	26 19·0	"
25·00 S.—NE. cor.—NW. ¼ sec. 23	29	23	5	" 18	26 23·5	"
6·00 E.—NE. cor. sec. 22	29	23	5	" 20	26 15·9	"
Course 3—2 Traverse of Is. N. in sec. 11	29	23	5	" 25	26 19·0	"
30·00 W.—NE. cor. sec. 10	29	23	5	" 29	26 13·9	"
" " 10	29	23	5	" 30	26 22·2	"
" " 10	29	23	5	Dec. 3	26 24·7	"
0·05 N.— " 24	70	23	5	Oct. 26	29 56·2	L. E. Fontaine.
11·37 N.— " 3	84	23	5	Aug. 16	31 48·8	"
59·54 W.— " 35	88	23	5	Sept. 19	32 05·9	A. H. Hawkins.
6·32 S.— " 3	71	24	5	Oct. 18	29 22·1	L. E. Fontaine.
0·23 N.— " 11	84	24	5	Aug. 21	30 57·6	"
75·59 W.— " 35	88	24	5	Sept. 27	32 07·6	A. H. Hawkins.
2·94 W.— " 32	88	24	5	" 28	32 00·0	"
19·85 W.— " 31	88	24	5	Oct. 3	31 44·6	"
At NE. cor. sec. 18	31	25	5	Sept. 9	26 11·0	N. C. Stewart.
12·00 W.—NE. cor. sec. 19	31	25	5	" 10	26 18·7	"
27·15 S — " 24	69	25	5	Oct. 24	29 08·4	L. E. Fontaine.
64·85 N.— " 23	70	25	5	" 15	29 06·8	"
32·46 W.— " 35	88	25	5	" 4	32 06·1	A. H. Hawkins.
At NE. cor. sec. 32	31	26	5	Aug. 14	26 15·4	N. C. Stewart.
46·00 W.—NE. cor. sec. 32	31	26	5	" 20	26 09·3	"
42·00 N.— " 31	31	26	5	" 22	26 09·8	"
2·00 N.— " 5	32	26	5	" 15	26 16·5	"

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date	Declination.		Observer.
30·00 N.—NE. cor. sec. 6	32	26	5	Aug. 23	26	30·4	N. C. Stewart.
30·00 N.— " 7	32	26	5	" 26	26	26·6	"
18·00 E.—NW. " 30	32	26	5	" 31	26	37·0	"
8·00 E.—NE. " 30	32	26	5	Sept. 2	26	37·0	"
18·00 E.— " 30	32	26	5	" 3	26	37·0	"
40·50 E.— " 30	32	26	5	" 3	26	26·9	"
63·00 E.— " 30	32	26	5	" 5	26	16·7	"
6·00 E.—NW. " 30	32	26	5	Aug. 29	26	47·7	"
41·73 N.—NE. cor. sec. 13	48	1	6	Aug. 22	27	32·2	J. A. Fletcher.
" " 13	48	1	6	" 22	27	39·2	"
" " 13	48	1	6	" 22	27	40·5	"
7·67 N.—SE. " 36	86	1	6	Oct. 18	31	53·0	J. R. Akins.
16·70 S.—NE. " 13	86	1	6	" 19	31	42·4	"
36·67 S.— " 1	86	1	6	" 21	31	37·4	"
32·90 E.— " 32	88	1	6	" 1	32	29·2	"
55·00 E.— " 33	88	1	6	" 1	32	27·8	"
17·16 E.— " 36	88	1	6	" 3	32	08·4	"
56·69 S.— " 34	88	1	6	" 14	32	21·8	"
58·53 N.— " 25	89	1	6	" 17	32	33·6	A. H. Hawkins.
64·47 N.— " 13	89	1	6	" 15	32	21·6	"
45·03 N.— " 24	89	1	6	" 16	32	27·2	"
6·81 N.— " 12	90	1	6	" 21	32	38·5	"
20·13 N.— " 24	90	1	6	" 22	31	41·9	"
0·47 N.— " 36	90	1	6	" 23	32	47·7	"
36·72 S.— " 33	84	2	6	Sept. 6	31	34·0	L. E. Fontaine.
5·84 N.— " 16	85	2	6	" 4	31	32·8	"
12·50 W.— " 31	88	2	6	" 20	33	06·7	J. R. Akins.
29·92 E.— " 33	88	2	6	" 24	33	05·3	"
6·11 E.— " 34	88	2	6	" 25	33	02·2	"
65·80 N.— " 33	83	3	6	Aug. 28	31	36·2	L. E. Fontaine.
3·32 N.— " 2	85	3	6	Sept. 1	31	30·9	"
38·59 W.— " 32	88	3	6	" 14	33	58·2	J. R. Akins.
5·51 W.— " 32	88	3	6	" 16	33	14·6	"
10·66 E.— " 36	88	3	6	" 19	33	08·9	"
64·38 S.— " 23	81	4	6	" 13	30	21·1	L. E. Fontaine.
24·19 E.—NW. " 32	88	4	6	" 5	32	12·0	J. R. Akins.
33·14 E.—NE. " 32	88	4	6	" 7	32	25·3	"
36·18 E.— " 33	88	4	6	" 9	32	27·3	"
16·34 W.— " 35	88	4	6	" 11	32	33·7	"
66·50 W.— " 36	84	5	6	Nov. 1	29	22·5	"
58·73 W.— " 34	84	5	6	" 2	29	23·9	"
11·48 N.— " 12	85	5	6	" 18	30	08·4	"
12·75 N.— " 24	85	5	6	" 20	30	33·1	"
66·81 N.— " 24	85	5	6	" 22	30	36·3	"
46·07 N.— " 36	86	5	6	" 23	31	00·6	"
17·20 N.— " 12	86	5	6	" 25	31	21·6	"
66·62 N.— " 12	86	5	6	" 26	31	27·4	"
6·48 N.— " 36	86	5	6	" 27	31	34·2	"
40·39 W.— " 31	88	5	6	Aug. 29	31	48·5	"
2·50 W.— " 31	88	5	6	" 29	31	51·6	"
28·96 E.— " 32	88	5	6	" 30	31	42·4	"
62·78 E.— " 33	88	5	6	" 31	31	48·8	"
4·55 W.— " 35	88	5	6	Sept. 2	31	49·4	"
3·23 E.— " 36	88	5	6	" 2	31	43·1	"
15·31 E.— " 36	88	5	6	" 4	32	04·0	"
17·00 S.— " 7	19	6	6	" 15	26	18·7	"
6·96 N.— " 23	74	6	6	" 19	29	10·8	L. E. Fontaine.
2·08 N.— " 23	75	6	6	" 27	29	48·3	"
0·41 S.— " 13	75	6	6	" 29	30	27·2	"
40·47 W.— " 36	84	6	6	Nov. 6	29	52·7	J. R. Akins.
3·14 W.— " 34	84	6	6	" 7	30	26·3	"
3·78 W.— " 33	84	6	6	" 8	30	59·3	"
At NE. cor. sec. 32	84	6	6	" 9	30	57·6	"
74·04 N.—NE. cor. sec. 1	85	6	6	Dec. 2	30	08·8	"
43·72 W.— " 31	88	6	6	Aug. 14	32	02·7	"
65·25 E.— " 31	88	6	6	" 15	32	01·7	"
28·40 W.— " 34	88	6	6	" 17	31	35·3	"
46·43 E.— " 35	88	6	6	" 28	31	40·4	"
40·30 S.— " 32	18	7	6	May 28	25	20·2	N. C. Stewart.
2·00 N.—SE. " 30	18	7	6	" 30	26	04·1	"
34·00 N.— " 6	19	7	6	" 31	26	31·6	"

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
4·75 S.—NE. cor. sec. 7	19	7	6	June 3	26 00·3	N. C. Stewart.
26·16 W.— " 32	88	7	6	Aug. 6	30 54·1	J. R. Akins.
39·35 E.— " 32	88	7	6	" 9	31 08·5	"
22·26 E.— " 35	88	7	6	" 13	31 51·4	"
5·00 N.— " 10	18	8	6	June 6	26 12·0	N. C. Stewart.
At NE. cor. sec. 11	18	8	6	" 10	25 18·1	"
At SE. " 2	18	8	6	" 14	25 31·1	"
At NE. " 15	18	8	6	Oct. 25	25 40·2	"
At NE. " 10	20	8	6	" 29	26 04·3	"
8·00 W.—NE. cor. SE. ¼ sec. 15	20	8	6	" 30	26 03·6	"
24·00 N.—NE. cor. SW. ¼ sec. 15	20	8	6	" 31	26 01·4	"
33·38 N.—NE. cor. sec. 27	74	8	6	" 5	30 13·9	L. E. Fontaine.
10·34 S.— " 12	75	8	6	" 5	30 00·3	"
39·76 E.— " 33	88	8	6	July 31	30 34·9	J. R. Akins.
" " 33	88	8	6	Aug. 1	30 35·4	"
38·07 E.— " 35	88	8	6	" 3	30 35·3	"
At NE. cor. sec. 22	19	9	6	" 26	24 57·0	M.P.Bridgland.
17·80 N.—NE. cor. sec. 15	19	9	6	Oct. 2	25 51·9	J. A. Fletcher.
" " 15	19	9	6	" 3	25 52·1	"
44·00 N.—SW. " 6	19	9	6	" 5	25 36·3	N. C. Stewart.
22·00 N.— " 7	19	9	6	" 7	25 43·9	"
52·00 N.— " 7	19	9	6	" 8	25 33·3	"
50·00 W.—NE. " 7	19	9	6	" 9	25 48·0	"
9·00 N.—SW. " 18	19	9	6	" 10	25 36·4	"
51·00 N.— " 18	19	9	6	" 11	25 30·6	"
30·00 N.—SE. " 19	19	9	6	" 15	25 25·7	"
3·50 N.— " 30	19	9	6	" 18	25 24·5	"
46·00 N.—NE. " 19	19	9	6	" 21	25 42·5	"
25·00 S.— " 31	19	9	6	" 23	25 36·7	"
12·00 N.—N. by sec. 6—W. by Okanagan I.R. No. 1	17	10	6	Sept. 26	25 29·0	"
Cor. of Jog—W. by Okanagan I.R. No. 1—Sec. 8	17	10	6	" 27	25 29·7	"
At NE. cor. sec. 32	19	10	6	Oct. 2	25 43·7	M.P. Bridgland.
" " 32	19	10	6	" 2	25 45·9	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	May 10	25 42·9	J. A. Fletcher.
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 10	25 42·6	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 11	25 39·2	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 11	25 37·3	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 13	25 43·1	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 13	25 42·5	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 14	25 44·1	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 15	25 43·1	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 16	25 43·8	"
1·50 N. 54° 33′ E. of NE. end of base line at Salmon Arm	20	10	6	" 17	25 44·4	"
37·00 S.—NE. cor. sec. 9	20	10	6	" 17	25 52·2	M.P. Bridgland.
" " 9	20	10	6	" 17	25 57·2	"
At NE. cor. sec. 9	20	10	6	June 9	25 57·8	"
" " 9	20	10	6	Nov. 6	25 54·3	"
" " 10	20	10	6	" 6	25 47·0	"
" " 5	20	10	6	" 6	26 07·7	"
40·25 S.—NE. cor. sec. 5	20	10	6	" 6	25 49·5	"
" " 5	20	10	6	Oct. 2	25 47·8	"
At NE. cor. sec. 4	20	10	6	Nov. 6	25 44·9	"
40·00 N.—NE. cor. sec. 29	23	14	6	Sept. 19	26 13·4	C. H. Taggart.
81·14 E.—NE. cor. S. ½ sec. 6	24	14	6	" 22	26 05·8	"
" " 6	24	14	6	" 22	26 13·2	"
" " 6	24	14	6	" 22	26 12·6	"
" " 6	24	14	6	" 22	26 09·5	"
" " 6	24	14	6	" 22	26 09·5	"
" " 6	24	14	6	" 22	26 06·4	"

MAGNETIC DECLINATION.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Declination.	Observer.
81.14 E.—NE. cor. S½ sec. 6	24	14	6	Sept. 22	26 12·6	C. H. Taggart.
" " 6	24	14	6	" 22	26 06·6	"
" " 6	24	14	6	" 22	26 10·7	"
" " 6	24	14	6	" 22	26 13·5	"
60·25 N.—NE. cor. sec. 8	24	14	6	" 28	25 57·9	"
60·00 N.— " 20	24	14	6	Oct. 5	26 17·4	"
10·00 N.— " 27	20	15	6	" 31	30 05·1	"
40·00 E.— " 34	20	15	6	" 30	29 26·3	"
At NE. cor. sec. 29	20	15	6	Nov. 4	27 52·9	"
40·25 E.—NW. cor. sec. 18	23	15	6	July 31	25 24·0	"
65·25 S —NE. " 11	24	15	6	Aug. 29	26 48·5	"
45·00 N.— " 3	24	15	6	" 19	25 40·3	"
48·00 E.— " 4	22	16	6	June 5	26 58·5	"
70·00 N.— " 3	22	16	6	" 20	26 50·6	"
54·00 N.— " 12	23	16	6	July 30	25 54·1	"
At NE. cor. sec. 3	26	16	6	" 26	25 49·3	"
4·50 E.—NE. cor. sec. 22	21	17	6	May 7	26 00·4	"
30·00 S.— " 23	21	17	6	" 7	26 15·1	"
40·00 W.— " 15	21	17	6	" 17	26 12·2	"
34·00 S — " 28	21	17	6	" 18	26 26·2	"
20·00 S — " 21	21	17	6	" 20	25 43·6	"
40·00 E.— " 23	22	17	6	" 29	26 32·6	"
1·00 W.— " 14	22	17	6	" 30	27 09·9	"
50·00 E.— " 15	18	18	6	Dec. 4	26 07·0	"
35·00 N.— " 23	18	18	6	" 6	26 02·5	"
At NE. cor. sec. 21	18	18	6	" 7	26 01·3	"
10·00 N.—NE. cor. sec. 10	18	18	6	" 12	26 18·0	"
31·57 W.—NE. cor. sec. 34	76	18	6	April 6	30 18·6	J. R. Akins.
66·92 W.— " 32	76	18	6	" 15	30 10·9	"
21·00 N.— " 21	84	18	6	May 10	31 40·3	L. Brenot.
20·00 N.— " 1	84	18	6	June 5	31 20·7	"
0·70 W.— " 35	76	19	6	April 18	29 58·2	J. R. Akins.
4·78 W.— " 35	76	19	6	" 18	29 56·8	"
26·43 W.— " 34	76	19	6	" 19	29 54·4	"
79·70 W.— " 34	76	19	6	" 20	29 52·8	"
47·84 W.— " 33	76	19	6	" 23	29 52·9	"
77·01 W.— " 32	76	19	6	" 24	29 50·8	"
77·01 W.— " 32	76	19	6	" 24	29 50·5	"
40·00 S.— " 36	83	19	6	July 31	31 47·8	L. Brenot.
At NE. cor. sec. 8	84	19	6	April 16	31 12·5	"
20·00 N.—NE. cor. sec. 24	84	19	6	" 22	31 32·5	"
11·00 S.— " 2	84	19	6	July 1	31 24·0	"
25·35 W.— " 36	76	20	6	April 25	29 56·9	J. R. Akins.
64·75 W.— " 31	76	20	6	May 6	30 22·4	"
48·00 W.— " 18	20	21	6	Dec. 13	25 14·5	J. A. Calder.
At NE. cor. sec. 36	76	21	6	May 7	30 30·2	J. R. Akins.
58·08 W.—NE. cor. sec. 36	76	21	6	" 8	30 32·8	"
50·38 W.— " 34	76	21	6	" 13	30 29·6	"
5·80 W.— " 33	76	21	6	" 14	30 36·9	"
13·28 W.— " 32	76	21	6	" 15	30 37·8	"
65·70 W.— " 31	76	21	6	" 20	30 44·5	"
0·50 W.— " 31	76	21	6	" 18	30 40·4	"
6·00 N.— " 24	20	22	6	Dec. 7	26 12·0	J. A. Calder.
30·73 W.— " 36	76	22	6	May 21	30 49·4	J. R. Akins.
58·53 W.— " 36	76	22	6	" 22	30 44·2	"
7·20 W.— " 34	76	22	6	" 24	30 47·9	"
9·03 W.— " 33	76	22	6	" 25	30 53·4	"
0·53 W.— " 32	76	22	6	" 27	31 03·1	"
17·90 W.— " 32	76	22	6	" 28	31 01·2	"
17·90 W.— " 32	76	22	6	" 29	31 03·8	"
73·31 W.— " 31	76	22	6	" 31	31 07·6	"
64·00 E.— " 32	83	22	6	Oct. 27	31 53·2	L. Brenot.
16·08 E.— " 1	14	23	6	Aug. 9	24 51·8	J. A. Calder.
5·00 W.— " 35	20	23	6	Nov. 29	27 26·8	"
40·26 W.— " 36	76	23	6	June 1	31 16·9	J. R. Akins.
23·30 W.— " 34	76	23	6	" 4	31 26·6	"
16·16 W.— " 32	76	23	6	" 7	31 24·3	"
At NE. cor. sec. 12	84	23	6	Oct. 24	32 01·4	L. Brenot.
7·60 S.—¼ on E. by sec. 29	16	24	6	June 22	26 45·3	J. A. Calder.
48·18 W.—NE. cor. sec. 35	76	24	6	" 12	31 12·5	J. R. Akins.
57·37 W.— " 34	76	24	6	" 13	31 07·7	"

MAGNETIC DECLINATION.—*Continued*

Place.	Tp.	Rge.	Mer.	Date.	Declin-ation.	Observer.
9·62 W.—NE. cor. sec. 33	76	24	6	June 15	31 01·9	J. R. Akins.
78·70 W.— " 33	76	24	6	" 17	31 04·3	"
31·57 W.— " 31	76	24	6	" 20	30 55·4	"
29·00 W.— " 33	16	25	6	July 10	25 04·2	J. A. Calder.
Sta. 27 Traverse left bank Thompson river	16	25	6	" 18	27 19·7	"
NW. cor. of Oregon Jack, I. R. No. 1	19	25	6	Dec. 18	26 05·7	"
17·19 W.—NE. cor. sec. 36	76	25	6	June 22	31 05·6	J. R. Akins.
41·44 W.— " 33	76	25	6	" 24	31 02·5	"
60·08 W.— " 31	76	25	6	" 29	31 17·9	"
8·00 N.— " 18	81	25	6	Sept. 17	31 24·8	L. Brenot.
Yola Cr. Traverse Sta. 73 Sec. 10	3	26	6	July 8	24 17·5	A. Lighthall.
About 15·00 NW.—¼ post N. by Sec. 13	3	26	6	" 27	25 14·2	"
20·50 SW.—SE. cor. T. B. 554, Bk. 2	4	26	6	Aug. 13	25 18·6	"
20·49 S.—NW. cor. T. B. 554, Bk. 2	4	26	6	" 14	25 37·5	"
9·55 E.—NE. cor. sec. 2	4	26	6	Nov. 19	23 57·4	"
At NE. cor. sec. SW. ¼ sec. 5	5	26	6	June 10	25 32·1	"
21·53 E.—NE. cor. sec. 35	7	26	6	Sept. 30	25 38·8	P. Melhuish.
55·13 W.—Centre sec. 26	8	26	6	May 24	25 58·6	"
52·00 E.—¼ post E. by sec. 22	8	26	6	June 1	26 19·2	"
74·70 S.—NE. cor. sec. 23	8	26	6	" 4	26 59·9	"
35·00 S.— " 14	8	26	6	" 5	28 05·5	"
At NE. cor. sec. 11	8	26	6	" 6	26 07·5	"
3·15 W.—NE. cor. sec. 1	8	26	6	" 18	25 16·3	"
20·02 S.— " 33	10	26	6	Nov. 7	25 57·9	"
43·00 S.— " 28	10	26	6	" 14	26 12·2	"
5·00 E.— " 21	10	26	6	" 15	26 11·4	"
3·00 N.—¼ cor.—N. by sec. 22	10	26	6	" 16	26 17·1	"
30·75 W.—NE. cor. sec. 28	11	26	6	Oct. 15	26 38·2	"
70·00 W.— " 28	11	26	6	" 16	26 09·6	"
30·00 N.— " 27	11	26	6	" 18	26 17·9	"
25·00 N.—¼ cor. N. by sec. 23	11	26	6	" 30	25 57·9	"
18·27 S.—NE. cor. sec. 15	11	26	6	" 4	25 55·1	"
51·46 S.— " 15	11	26	6	" 5	25 44·9	"
At NE. cor. sec. 15	11	26	6	" 7	25 50·5	"
2·60 N.—¼ cor.—N. by sec. 15	11	26	6	" 8	25 53·2	"
3·55 W.—Centre sec. 22	11	26	6	" 9	25 59·5	"
4·82 E.—¼ cor.—E. by sec. 21	11	26	6	" 10	26 05·2	"
14·97 S.—NE. cor. sec. 21	11	26	6	" 11	26 15·4	"
34·21 N.— " 21	11	26	6	" 12	26 10·5	"
At NE. cor. sec. 28	11	26	6	" 14	25 27·8	"
10·00 W.—NE. cor. lot 1471	15	26	6	" 27	26 20·1	J. A. Calder.
Centre sec. 10	16	26	6	Nov. 13	25 54·6	"
9·70 W.—NE. cor. sec. 35	76	26	6	July 2	31 15·1	J. R. Akins.
10·00 N.— " 13	81	26	6	Aug. 30	31 21·2	L. Brenot.
70·25 E.—NW. " 31	4	27	6	Nov. 6	24 20·2	A. Lighthall.
37·72 E.— " 30	4	27	6	" 15	24 04·7	"
63·29 N.—NE. " 24	12	27	6	" 25	26 09·1	P. Melhuish.
20·00 E.— " 25	12	27	6	" 27	25 39·8	"
65·00 E.— " 25	12	27	6	" 28	25 55·2	"
Sta. 66 Traverse right bank Stein river	15	27	6	Aug. 28	26 17·9	J. A. Calder.
28·00 E.—NW. cor. sec. 9	4	28	6	Dec. 6	26 15·0	A. Lighthall.
15·00 E.—NE. " 29	15	28	6	Sept. 12	26 11·4	J. A. Calder.
8·00 E.— " 34	15	29	6	Oct. 9	25 54·3	"
10·00 E.— " 15	6	5	7	" 1	26 01·5	A. Lighthall.
10·00 S.— " 29	6	5	7	Sept. 19	25 27·7	"
4·00 E.—NW. " 2	6	7	7	Aug. 21	26 34·0	"
5·00 W.—NE. " 12	6	7	7	Sept. 4	25 50·2	"
5·00 S.— " 20	19	......	E.C.	Oct. 12	24 57·5	"

MAGNETIC DIP AND TOTAL INTENSITY.

Place.	Tp.	Rge.	Mer.	Date.	Time.	Dip.	Time.	Total Intensity. c.g.s.	Observer.
40·00 W. 10·00 S.—NE. cor. sec. 18	40	22	3	14–10–10	9.03 A	77 26·8	9.30 A	·62752	D. E. Chartrand.
" "	40	22	3	14–10–10	9.58 A	77 26·3	10 25 A	·62773	"
10·00 S. 15·00 E.—¼ p. W. by 31	37	24	3	23–10–10	1.57 P	77 15·2	2.27 P	·62519	"
" "	37	24	3	23–10–10	2.54 P	77 13·9	3 19 P	·62563	"
5·00 S.—¼ p. E. by sec. 9	21	4	2	15– 6–10	3.30 P	77 42·8	4 10 P	·63169	"
" "	21	4	2	15– 6–10	4·45 P	77 39·7	5.25 P	·63164	"
" "	21	4	2	15– 6–10	5.57 P	77 41·5	....	....	"
" "	21	4	2	19– 6–10	8.47 A	77 43·5	9 30 A	·63176	"
" "	21	4	2	19– 6–10	10·07 A	77 43·0	10.40 A	·63171	"
" "	21	4	2	19– 6–10	11.15 A	77 43·6	....	....	"
30·00 W. 10·00 S.—NE. cor. sec. 3	35	1	3	31– 7–10	9.18 A	77 34·5	9·51 A	·63488	"
20·00 S. 3·00 E.—NE. cor. sec. 12	34	3	3	3– 8–10	1.45 P	77 38·9	2.27 P	·63364	"
" "	34	3	3	3– 8–10	3.07 P	77 39·8	3.35 P	·63359	"
22·00 N. 35·00 W.—SE. cor. sec. 9	33	4	3	10– 8–10	2.24 P	77 19·7	3.09 P	·63179	"
15·00 N. 14·00 W.—NE. cor. sec. 36	38	5	3	12– 8–10	2.21 P	77 52·1	2.56 P	·62991	"
" " 36	38	5	3	12– 8–10	3.34 P	77 53·2	4.09 P	·63004	"
At NE. cor. sec. 29	22	6	2	9– 6–10	2.46 P	77 48·8	3.39 P	·63061	"
" "	22	6	2	9– 6–10	4.24 P	77 48·5	4.54 P	·63122	"
" "	22	6	2	9– 6–10	5.24 P	77 50·3	....	....	"
" "	22	6	2	12– 6–10	9.49 A	77 49·9	10.36 A	·63103	"
" "	22	6	2	12– 6–10	11.16 A	77 50·5	11.54 A	·63167	"
" "	22	6	2	12– 6–10	12.24 P	77 50·7	....	....	"
22·00 N. 35·00 W.—SE. cor. sec. 9	33	4	3	9–10–10	9.39 A	77 21·6	10.06 A	·63103	"
" "	33	4	3	9–10–10	10.39 A	77 22·3	11.09 A	·63104	"
5·00 N. 25·00 W.—NE. cor. sec. 22	32	16	2	17– 7–10	9.25 A	78 15·6	10·00 A	·63355	"
" "	32	16	2	17– 7–10	10.28 A	78 16·1	10·58 A	·63238	"
" "	32	16	2	17– 7–10	11.30 A	78 15·8	....	....	"
10·00 W.—Centre sec. 36	32	20	2	27– 7–10	7.13 P	78 03·4	7.43 P	·63304	"
30·00 W.—NE. cor. sec. 3	35	1	3	30– 7–10	4.36 P	77 35·7	5.01 P	·63551	"
" "	35	1	3	30– 7–10	5.31 P	77 33·0	5.58 P	·63587	"
" "	35	1	3	30– 7–10	6.36 P	77 33·4	....	....	"
At NE. cor. sec. 8	26	12	2	6– 7–10	2.15 P	77 53·1	2.47 P	·63163	"
" "	26	12	2	6– 7–10	3.20 P	77 53·7	4.00 P	·63138	"
" "	26	12	2	6– 7–10	4.30 P	77 54·3	....	....	"
3·00 E. of. NE. cor. sec. 22	33	22	2	16– 7–10	1.30 P	78 01·0	2.02 P	·63286	"
" "	33	22	2	16– 7–10	2.30 P	78 02·6	2.55 P	·63215	"
" "	33	22	2	16– 7–10	3.25 P	78 02·1	....	....	"
20·00 N.—NE. cor. sec. 17	36	27	Pr.	31– 5–10	3.05 P	79 05·2	3.52 P	·63924	"
" "	36	27	Pr.	31– 5–10	4.47 P	79 04·7	....	....	"
" "	36	27	Pr.	1– 6–10	9.25 A	79 10·8	10.17 A	·63872	"
" "	36	27	Pr.	1– 6–10	11.00 A	79 10·3	....	....	"

20 00 N—NE. cor. sec. 17	36	27	Pr.	3- 6-10	1.05 P	79 05·9	1.42 P	·63915	D. E. Chartrand.
" "	36	27	Pr.	3- 6-10	2.25 P	79 05·9	2.57 P	·63921	"
" "	36	27	Pr.	3- 6-10	3.32 P	79 06·1			"
5·00 N. 15·00 E.—¼ E. by 29	45	21	2	1- 9-10	9.20 A	79 01·1	10.00 A	·63019	"
" "	45	21	2	1- 9-10	10.35 A	79 04·3	11·10 A	·62993	"
20·00 S.—SE. cor. sec 5	49	26	2	3- 9-10	1.57 P	79 13·5	2.32 P	·63381	"
" "	49	26	2	3- 9-10	3.00 P	79 12·9	3.30 P	·63441	"
At ¼ post W. by sec. 30	43	16	3	12- 9-10	11·24 A	77 42·3	12.00 M	·62755	"
" "	43	16	3	12- 9-10	12.32 P	77 42·3	1.12 P	·62752	"
20·00 S. 20·00 E.—NW. cor. sec. 7	45	18	2	6-10-10	9.49 A	79 03·2	10.22 A	·63142	"
" "	45	18	2	6-10-10	10 54 A	79 03·0	11.27 A	·63205	"
15·00 W.—NE. cor. sec. 18	48	25	3	25- 9-10	9 36 A	78 18·5	10.11 A	·62744	"
" "	48	25	3	25- 9-10	10.48 A	78 20·2	11.26 A	·62742	"
10·00 S. 10·00 E.—¼ P.W. by 6	39	2	3	29- 9-10	8.10 A	78 15·2	8.40 A	·63393	"
" "	39	2	3	29- 9-10	9.12 A	78 14·8	9.52 A	·63537	"
20·00 S.—SE. cor. sec. 5	49	26	2	1-10-10	10.07 A	79 13·3	10.39 A	·63447	"
" "	49	26	2	1-10-10	11.09 A	79 15·3	11.37 A	·63394	"
10·00 S. 5·00 E.—NE. cor. 19	37	22	2	18- 8-10	8.45 A	78 28·7	9.20 A	·63292	"
" "	37	22	2	18- 8-10	9 52 A	78 29·6	10.25 A	·63297	"
30·00 S. 5·00 E.—NE. cor. 34	42	3	3	23- 8-10	8.25 A	78 14·6	9 02 A	·63695	"
" "	42	3	3	23- 8-10	9.47 A	78 15·3	10.27 A	·63666	"
At NE. cor. sec. 12	49	4	3	27- 8-10	9.44 A	78 45·1	10.24 A	·62920	"
" "	49	4	3	27- 8-10	10.59 A	78 45·4	11.31 A	·62964	"
Churchill East Peninsula—Lat 58° 47′ 34″, long. 94° 10′ 00″				23- 8-08	11.48 A	84 38·0	12.44 P	·63740	J. E. Morrier.
				23- 8-08	3.11 P	84 36·8	11.32 A		"
" " " "				30- 8-08	11.32 A	84 41·3	12.34 P	·63567	"
" " " "				30- 8-08	3.48 P	84 34·1	4 27 P	·63593	"
Churchill West Peninsula—Lat. 58° 46′ 47″, long. 94° 11′ 00″				22- 9-08	10 55 A	84 33·5	11.55 A	·64007	"
" " " "				22- 9-08	2.05 P	84 35·1	2 50 P	·63681	"
" " " "				1-11-08	11.20 A	84 35·4	12.17 P	·63987	"
" " " "				1-11-08	1.00 P	84 36·9	1 36 P	·63876	"
H. B. Post, Norway House—Lat. 53° 58′ 00″, long. 97° 52′ 00″				18- 6-08	10.44 A	80 58·9	12.01 P	·63876	"
				18- 6-08	1.35 P	80 58·2	2.28 P	·63769	"
" " " "				21- 6-08	10.14 A	80 58·0	11 14 A	·63887	"
				21- 6-08	1.38 P	80 57·1	2 22 P	·63978	"
H. B. Post, Oxford House—Lat. 54° 53′ 30″, long. 95° 45′ 00″				27- 6-08	12.12 P	82 31·6	12 57 P	·64218	"
				27- 6-08	2.19 P	82 31·9	2.54 P	·64093	"
H. B. Post, York Factory—Lat. 57° 00′ 00″, long. 92° 28′ 00″				7- 7-08	4.48 P	83 32·9	5.35 P	·63234	"
				8- 7-08	9 52 A	83 27·4	10.24 A	·63413	"
" " " "				8- 7-08	2.24 P	83 27·0			"
" " " "				8- 7-08	5 20 P	83 30·9	5 57 P	·63486	"
" " " "				10- 7-08	9.04 A	83 27·5	9.46 A	·63539	"
" " " "				10- 7-08	10 40 A	83 36·3	11.12 A	·63200	"
71·11 N. 71·01 E.—NE. cor. sec. 7	66	22	4	19- 5-10	10 40 A	78 04·5	11.24 A	·62146	Carl Engler.
" "	66	22	4	19- 5-10	12.10 P	78 03·1			"
" "	66	22	4	20- 5-10	2.32 P	78 04·3	3.27 P	·62137	"
	66	22	4	20- 5-10	3 44 P	78 00·6			"
Grand Rapids, Athabaska river	84	17	4	31- 5-10	10 04 A	79 28·5	11.18 A	·62259	J. A. Cote.
" "	84	17	4	31- 5-10	12 42 P	79 28·6			"
" "	84	17	4	1- 6-10	9 30 A	79 27·3	10·21 A	·62217	Carl Engler.
" "	84	17	4	1- 6-10	11.06 A	79 26·8			"

MAGNETIC DIP AND TOTAL INTENSITY.—*Continued.*

Place.	Tp.	Rge.	Mer.	Date.	Time.	Dip.	Time.	Total Intensity. c.g.s.	Observer.
Below Boiler Rapids, Athabaska river	......	......	......	5– 6–10	5.57 P	79 31·2	6.32 P	·62913	Carl Engler.
Big Cascade, Athabaska river	......	......	......	7– 6–10	4.22 P	79 39·1	5.00 P	·62372	J. A. Cote.
" "	......	......	......	7– 6–10	5.32 P	79 42·9	....	....	"
Fort McMurray, S. shore Athabaska river, opp. island	......	......	......	10– 6–10	3.22 P	79 58·1	4.00 P	·62700	"
" " " "	......	......	......	10– 6–10	4.24 P	79 57·7	....	....	Carl Engler.
" " " "	......	......	......	13– 6–10	2.11 P	80 00·1	3.00 P	·62566	"
" " " "	......	......	......	13– 6–10	3.39 P	79 58·1	....	....	"
Fort Chipewyan	......	......	......	17– 6–10	3.33 P	81 08·2	4 03 P	·62588	J. A. Cote.
Smith Landing, SW. cor. H. B. Co. Res	......	......	......	23– 6–10	3.42 P	81 55·0	4.20 P	·65489	"
" "	......	......	......	23– 6–10	4.54 P	81 49·4	....	....	Carl Engler.
Ft. Smith, near Observing Tent	......	......	......	11– 7–10	4.20 P	81 57·3	5.05 P	·62259	J. A. Cote.
" "	......	......	......	12– 7–10	3.27 P	81 57·9	4.16 P	·62153	"
" "	......	......	......	12– 7–10	4.55 P	81 59·0	....	....	"
Fort Chipewyan	......	......	......	6– 8–10	10.43 A	81 09·7	12·24 P	·62391	Carl Engler.
"	......	......	......	6– 8–10	1.20 P	81 09·2	....	....	"
Ft. McMurray, Point of Mag. Observations	......	......	......	10– 8–10	9.19 A	80 02·8	10.09 A	·62547	"
" " "	......	......	......	10– 8–10	10.49 A	80 00·1	....	....	"
Grand Rapids, E. shore of river	......	......	......	24– 8–10	10.15 A	79 28·5	10.52 A	·62134	"
" "	......	......	......	24– 8–10	11.22 A	79 29·6	....	....	"